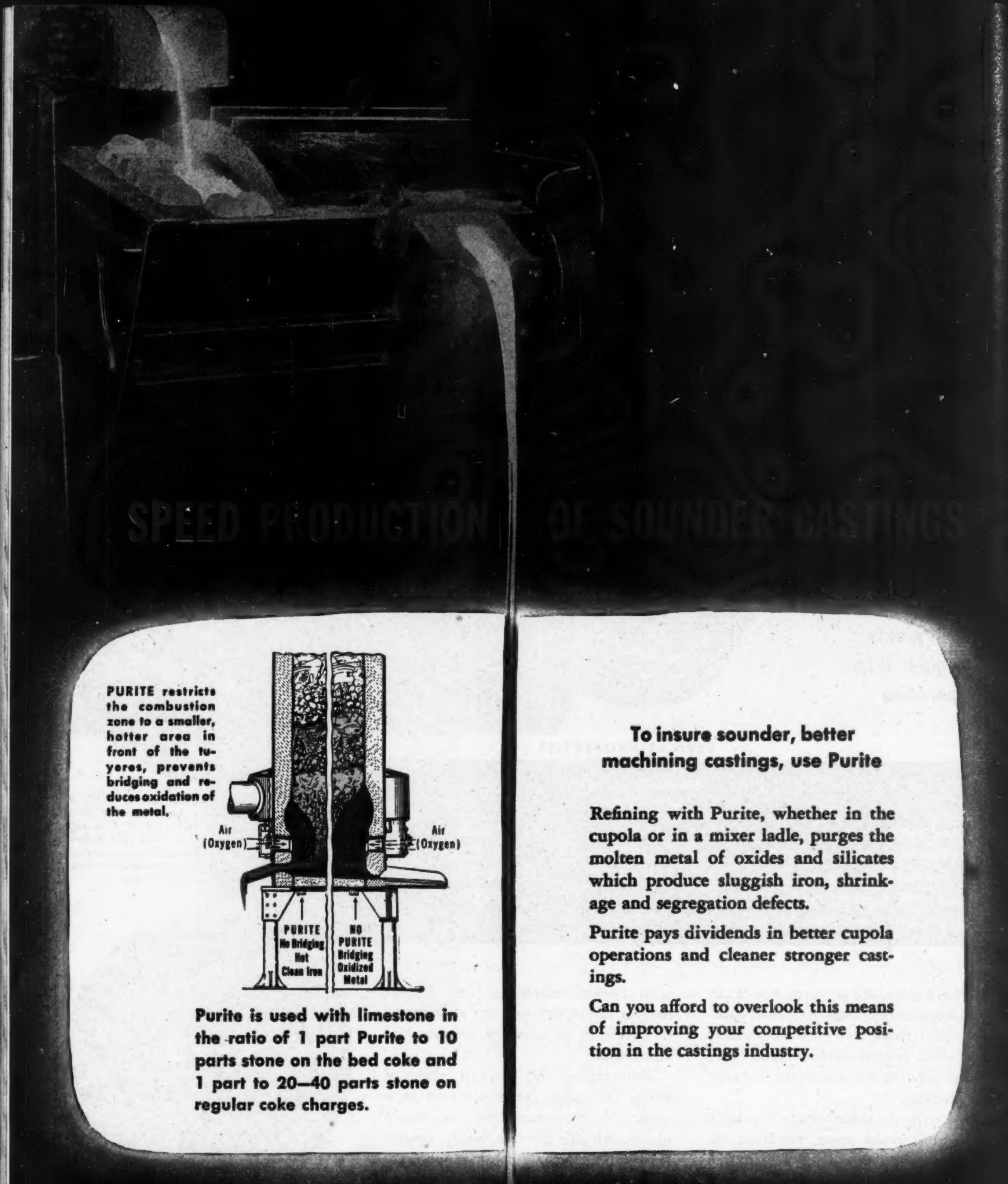
American Foundryman

"The FOUNDRYMEN'S OWN MAGAZINE"

Cleaning Bogie Wheels

Who Are the Authors in This Issue?, See Page 4. President Teetor's Message, See Page 32. Effect of Gas on Magnesium, See Page 34. Steel Castings Radiography, See Page 49. SAE War Engineering Board Report, See Page 68.

May 1945



SPEED PRODUCTION OF SOUNDER CASTINGS
PURITE restricts the combustion zone to a smaller, hotter area in front of the tuyeres, prevents bridging and reduces oxidation of the metal.
Air (Oxygen)
Air (Oxygen)
PURITE No Bridging Hot Clean Iron
NO PURITE Bridging Oxidized Metal
Purite is used with limestone in the ratio of 1 part Purite to 10 parts stone on the bed coke and 1 part to 20—40 parts stone on regular coke charges.
To insure sounder, better machining castings, use Purite
Refining with Purite, whether in the cupola or in a mixer ladle, purges the molten metal of oxides and silicates which produce sluggish iron, shrinkage and segregation defects.
Purite pays dividends in better cupola operations and cleaner stronger castings.
Can you afford to overlook this means of improving your competitive position in the castings industry.
THE SCIENTIFIC FLUX FOR BETTER MELTING AND CLEANER IRON
PURITE
THE MATHIESON ALKALI WORKS (INC.)
60 EAST 42nd STREET, NEW YORK 17, N. Y.
(Licensee of Metallurgical Development Company, Inc.)
In Canada: Railway & Power Engineering Corporation, Limited

American Foundryman

MAY 1945

VOLUME VII
NUMBER 5

Page

Who Are the Authors in This Issue? 4

President R. J. Teetor's Message to Members 32

Effect of Gas on the Properties of Magnesium Sand Casting Alloys, by R. S. Busk, R. F. Marande and W. C. Newhams 34

Purpose of Committee on the Inspection of Castings, by H. W. Warner 44

Effect of Composition on the Mechanical Properties of Sand Cast Copper-Tin-Lead-Zinc Alloys, by Walter T. Battis 45

Steel Castings Radiography, by E. L. LaGrelius and C. W. Stephens 49

Increased Use of Gray Cast Iron in High Temperature Operations, by C. O. Burgess and T. E. Barlow 57

The Post War Outlook for the Foundry Industry, by E. F. Platt . 66

SAE War Engineering Board Report 68

War Production Conference 72

New Association Members 73

Chapter Activities 75

Schedule of May Chapter Meetings 77

Abstracts of Current Foundry Literature 82

Index to Advertisers 5

The American Foundrymen's Association is not responsible for statements or opinions advanced by authors of papers printed in its publications.

Published by the American Foundrymen's Association, Inc., 222 West Adams St., Chicago, Ill., for the purpose of presenting Association and Chapter activities. Published monthly. Subscription price, to members, $1.00 per year; to non-members, $1.50 per year. Single copies, 20c.

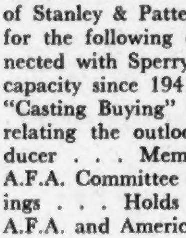
Entered as second class matter July 22, 1938, at the post office at Chicago, Illinois, under the Act of March 3, 1879

WHO ARE THE AUTHORS *In This Issue?*

The men whose names are shown on these two pages deserve the thanks of the industry for their contributions to the 1945 "Year-'Round Foundry Congress" . . . in many cases, completed in spite of cancellation of the Detroit convention.

Eugene Platt

Author of a forward-looking paper in this issue on *"The Post-War Outlook for the Foundry Industry"* . . . Castings and patterns buyer for Sperry Gyroscope, Inc., Brooklyn, N. Y. . . . A castings buyer looks at the industry . . . Birthplace at Trenton, N. J. (September, 1912) . . . Elementary and high school education received in Trenton . . . A graduate of St. John's University, Brooklyn, with a B.A. degree . . . From May, 1930 to 1932, in production control capacity with H. Buker & Sons, Inc., New York City . . . Served as Production Assistant to the Vice-president of Stanley & Patterson, Inc., New York, for the following eight years . . . Connected with Sperry Gyroscope in present capacity since 1941 . . . Has written on "Casting Buying" for *Printer's Ink*, correlating the outlook of buyer and producer . . . Member and secretary of A.F.A. Committee on Inspection of Castings . . . Holds membership in both A.F.A. and American Society for Metals.

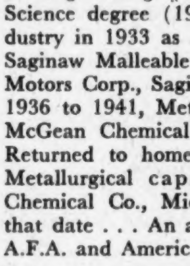


E. L. La Grelius

In this issue: see *"Steel Castings Radiography"* . . . co-authored by La Grelius with C. W. Stephens . . . Mr. La Grelius is a native of Illinois by birth, and Supervising Metallurgist of American Steel Foundries, East Chicago, Ind., by profession . . Born in Port Byron, Ill., in 1907 on the "Old Mississippi" . . . Early education at schools in near-by East Moline . . . Holds three separate degrees from three separate institutions . . . Earned his B.S. degree at St. Ambrose College in 1932 . . . His M.S. at the University of Illinois in 1933 . . . Added an LL.B. in 1941 at Lincoln College of Law . . . Prior to college training, served his apprenticeship as a tool and die maker . . . This "hard-way learning" at Moline Pressed Steel Co., East Moline . . . Materials Engineer for the Illinois State Department of Public Works and Buildings, 1935-1941 . . . Associated with American Steel Foundries in present metallurgical capacity for the past four years . . . Author of several papers on radiography and chemical subjects . . . Presented before meetings of A.S.T.M., A.F.A., A.I.M.E. . . . Member of A.F.A., A.S.T.M., and American Industrial Radium and X-ray Society.

Russell F. Marande

See paper in this issue on *"Effect of Gas on the Properties of Magnesium Sand Casting Alloys"* . . . Authored by Mr. Marande and associates W. C. Newhams and R. S. Busk . . . This Metallurgist for Dow Chemical Co., born May, 1910 at Bay City, Mich. . . . Engineering training obtained at the University of Michigan . . . Degrees include B.S. in Engineering (1932) and Master of Science degree (1933) . . . Entered industry in 1933 as Assistant Metallurgist, Saginaw Malleable Iron Div. of General Motors Corp., Saginaw, Mich. . . . From 1936 to 1941, Metallurgist Engineer for McGean Chemical Co., Cleveland . . . Returned to home State in 1941 . . . Metallurgical capacity with the Dow Chemical Co., Midland, Mich., since that date . . . An active member of both A.F.A. and American Society for Metals.



C. W. Stephens

Co-author, with E. L. La Grelius, of valuable paper on radiography in this issue . . . Titled: *"Steel Castings Radiography"* . . . Mr. Stephens born 1912 at Camden, N. J. . . . Preparatory schools of West Palm Beach, Fla., gave him his early education . . . Studied at St. Charles College, Louisiana . . . Began his business career in Florida and New York in the hotel business . . . Entered foundry industry and joined American Steel Foundries, Granite City Works, in 1940 . . . Quickly became interested in radiography as an industrial tool . . . Appointed Foreman of X-ray Department at Granite City Works in 1942, his present capacity . . . A member of the American Industrial Radium and X-ray Society.

Walter T. Battis

Author of paper herein on the *"Effect of Composition on the Mechanical Properties of Sand-Cast Copper-Tin-Lead-Zinc Alloys"* . . . A native of Boston, born there in 1913 . . . Preparatory education received at Roxbury Latin School . . . Earned his Bachelor of Science degree at Yale University Engineering School in 1935 . . . Has been associated with the Federated Metals Div. of American Smelting & Refining Co. ever since graduation . . . First position after college, Research Metallurgist at the Perth Amboy, N. J., plant . . . From 1936 to 1939, Research Metallurgist at the Pittsburgh, Pa., plant . . . The following year in like capacity at the Detroit plant . . . 1939-1944, returned to Perth Amboy plant, also as Research Metallurgist . . . Appointed Assistant Superintendent of the Brass Department last year . . . An active member of the American Foundrymen's Association and American Institute of Metallurgical Engineers.

W. C. Newhams

Metallurgist for the Dow Chemical Co., Bay City, Mich. . . . Co-author, with associates R. S. Busk and R. F. Marande, of magnesium paper in this issue . . . Paper covers the *"Effect of Gas on the Properties of Magnesium Sand Casting Alloys"* . . . Mr. Newhams born in Pittsburgh, Pa., September, 1915 . . . Elementary schooling in the "Smoky City" . . . Received his Bachelor of Science degree from Carnegie Institute of Tech-

nology in 1940 . . . Immediately after graduation, joined Dow Chemical as Metallurgist in their Midland, Mich., plant . . . Present position at Bay City, Mich., plant since 1942 . . . In addition to his American Foundrymen's Association membership, also active in the American Society of Metals.

Robert S. Busk

Metallurgist for Dow Chemical Co. . . . Part-author of paper in this issue on *"Effect of Gas on the Properties of Magnesium Sand Casting Alloys"* . . . Co-authors, R. F. Marande and W. C. Newhams . . . Bob Busk is a native of Brooklyn, N. Y., where he was born in 1915 . . . Preparatory education was received at Poughkeepsie, N. Y., High School . . . Higher education first undertaken at Colgate University . . . Merited a Bachelor of Arts degree there . . . Went on to Yale University to earn the degree of Doctor of Engineering . . . Became associated with Dow Chemical Co. as Metallurgist in their Midland, Mich., plant in June, 1940 . . . connected with the Dow company ever since . . . Known for his work in magnesium metallurgy . . . Has prepared papers on this subject before meetings of A.S.T.M., A.I.M.E., and A.F.A. . . . Also a member of American Society for Metals

---

T. E. Barlow

Research Engineer for Battelle Memorial Institute, Columbus, Ohio . . . Colaborator with C. O. Burgess on abstracted report *"Increased Use of Gray Cast Iron in High Temperature Operations"* . . . A graduate of the University of Michigan . . . Active member of several A.F.A. Committees, particularly on Gray Iron and Castings Analysis . . . Formerly Foundry Engineer, Vanadium Corp. of America, Detroit . . . Became associated with Battelle in 1944 . . . Member of A.F.A. and American Society for Metals.

C. O. Burgess

See in this issue: *"Increased Use of Gray Cast Iron in High Temperature Operations,"* from a War Metallurgy Committee report . . . abstracted jointly by C. O. Burgess and T. E. Barlow . . . Mr. Burgess is Research Metallurgist for Union Carbide and Carbon Research Laboratories, Niagara Falls, N. Y. . . . Born 1902 at Little Falls, N. Y. . . . A graduate of Lehigh University in Metallurgical Engineering . . . connected with Union Carbide and Carbon ever since leaving college in 1923 . . . A widely known author of papers on cast irons, tool steels and ferrous alloys . . . Chairman of A.F.A. Gray Iron Division . . . An active member of A.F.A., A.S.M. and A.S.T.M.

ADVERTISERS IN THIS ISSUE

Page

A

Air Reduction Sales Co. 95
American Air Filter Co., Inc. 28-29
American-British Chemical Supplies, Inc. 102
American Chain & Cable Co., Inc. 98
American Smelting & Refining Co., Federated Metals Div. 22
Atlas Publishing Co. 26

B

Baker Perkins, Inc. 99
Black Donald Graphite, Ltd. 18

C

Cleveland Tramrail Division, The Cleveland Crane & Engineering Co. .... Cover II
Chain Belt Co. 9
Conover Engineering Co. 97
Continental Machines, Inc. 19

D

Dayton Oil Co. 83
Despatch Oven Co. .... Cover IV
Dietert, Harry W., Co. 13
Dougherty Lumber Co. 90

E

Eastern Clay Products, Inc. 25
Eastman Kodak Co. 84-85
Electro Metallurgical Co. 20-21
Elematic Equipment Corp. 92

F

Foundry Services, Inc. 100

G

General Electric X-Ray Corp. 6-7
Great Western Mfg. Co. 103

H

Hanna Furnace Corp. 91
Harrison Abrasive Corp. 108
E. F. Houghton & Co. 93
Hydro-Blast Corp. 10-11

I

Industrial Equipment Co. 105
International Nickel Co. 1

Page

J

Jackson Iron & Steel Co. 104
Jeffrey Mfg. Co. 107

K

Kramer, H., & Co. 106

L

Lavin, R., & Sons, Inc. 109
Logan Co. 12

M

Master Tool Co. 88
Mathieson Alkali Works, Inc. 2

N

National Engineering Co. 27

P

Parsons Engineering Corp. 89
Pendergast, Geo. M., & Co. 104
Pennsylvania Foundry Supply & Sand Co. 94
Picker X-Ray Corp. 86-87
Pittsburgh Lectromelt Furnace Corp. 17

S

Schneible, Claude B., Co. 24
Silverstein & Pinsof, Inc. 101
Stevens, Frederic B., Inc. 8
Sullivan Machinery Co. 23

T

Tabor Mfg. Co. 96
Tonawanda Iron Corp. 16

U

U. S. Hoffman Machinery Corp. 112

V

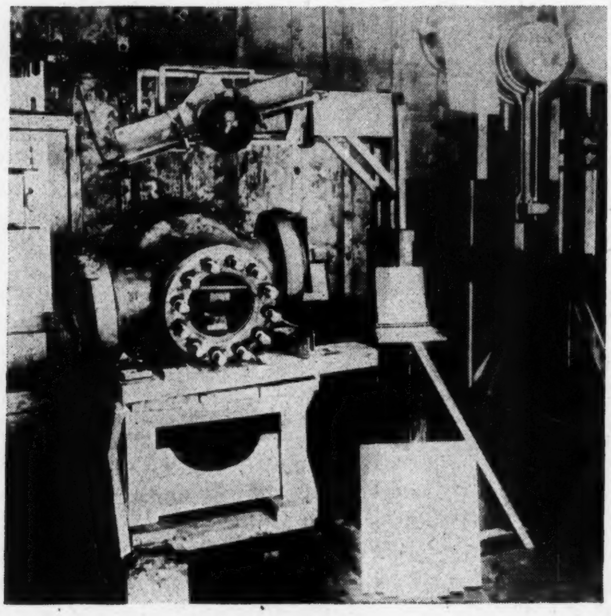
Vanadium Corp. of America 30
Velsicol Corp. 111

W

Western Metal Abrasives Co. 97
Whiting Corp. 14-15
Wilson, Lee, Engineering Co., Inc. 110

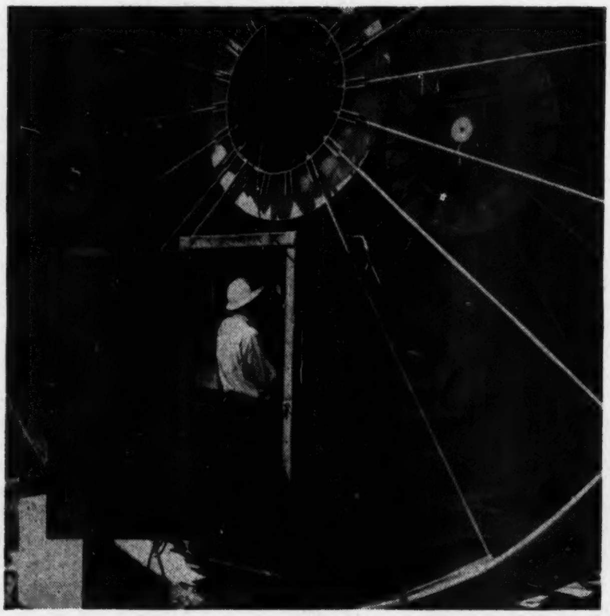
THEN . . . NOW . . .

G-E X-Ray Industrial Equipment



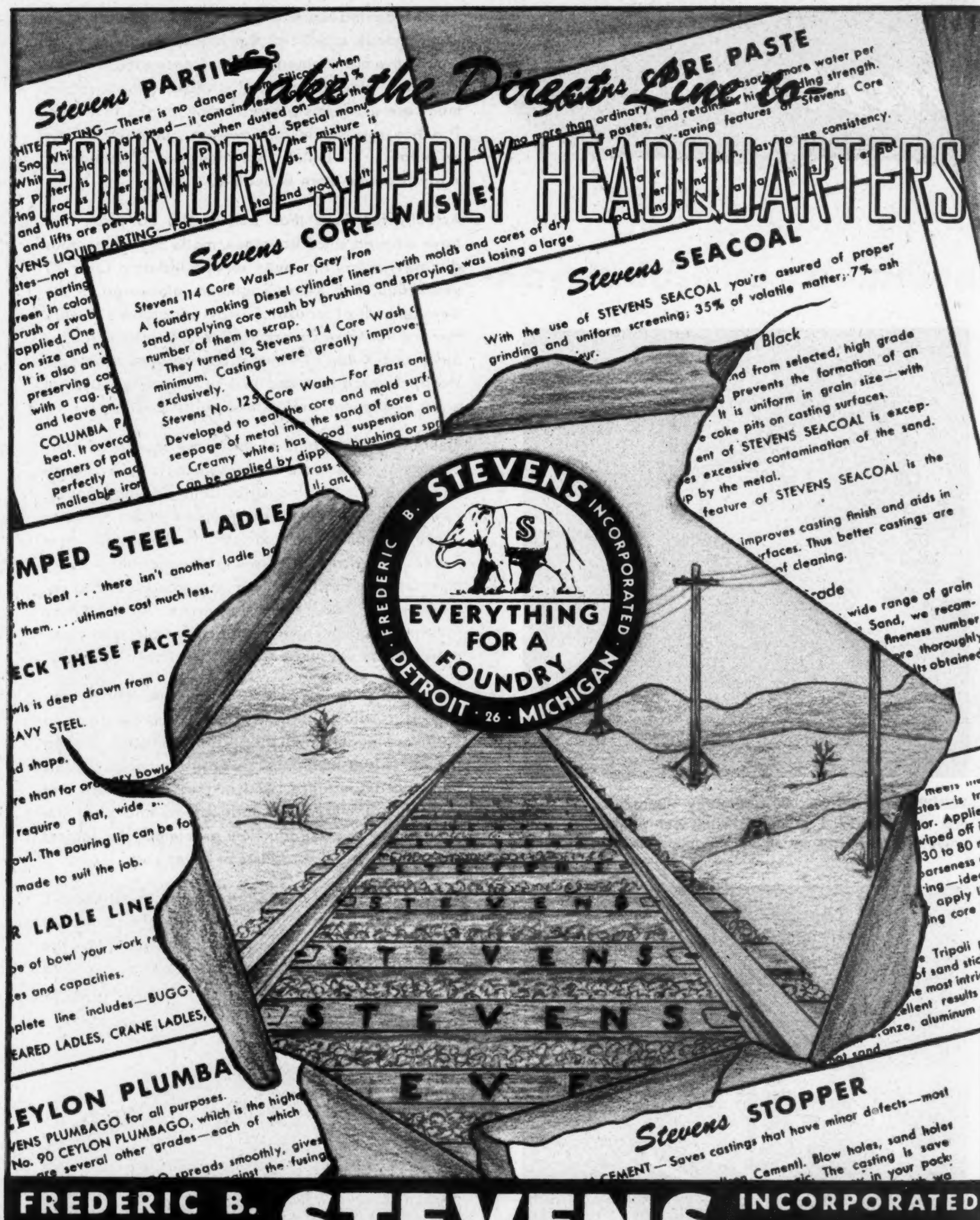
THEN . . . a decided contrast to the compact, multi-powered G-E X-Ray industrial equipment available today, was this pioneer installation in a leading arsenal—made in 1922.

NOW . . . aircraft, armament, and ordnance plants—foundries producing castings of every size and type—are among the many industries served by modern G-E X-Ray Units.



In the years following its introduction, applications of industrial x-ray steadily increased—included such uses as penstock inspection on many great dam construction jobs.

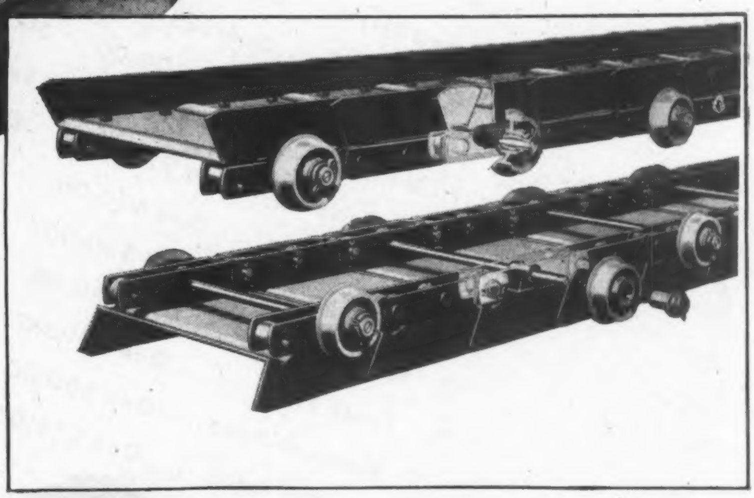
Ever growing demands for light alloy castings necessitate speedier production—G-E X-Ray fluoroscopic inspection units provide a rapid visual method of checking quality.


Take the Direct Line to—
FOUNDRY SUPPLY HEADQUARTERS
Stevens PARTINGS
Stevens CORE PASTE
Stevens CORE WASHES
Stevens SEACOAL
STAMPED STEEL LADLES
CHECK THESE FACTS
LADLE LINERS
CEYLON PLUMBAGO
Stevens STOPPER
FREDERIC B. STEVENS INCORPORATED
EVERYTHING FOR A FOUNDRY
DETROIT · 26 · MICHIGAN
FREDERIC B. STEVENS INCORPORATED
DETROIT · 26 · MICHIGAN
• NEW ENGLAND . 166-182 Brewery St., New Haven, Conn.
• NEW YORK and PENNSYLVANIA, 93 Stone St., Buffalo, N. Y.
• INDIANA . Hoosier Supply Co., 36 Shelby St., Indianapolis, Ind.
• CANADA . FREDERIC B. STEVENS OF CANADA, LIMITED
• 1262 McDougall St. Windsor, Ontario
• 2368 Dundas St., West Toronto, Ontario

DO YOU WANT MORE CAPACITY FROM YOUR PRESENT SPACE?

① **YOU CAN INCREASE** your output without increasing floor space by installing a modern and efficient conveyor system. That's why it will pay you to investigate Rex Foundry Handling Systems that assure a smooth, low-cost "work flow" throughout the entire production cycle.

② **FOR EXAMPLE,** here, in the world's largest valve manufacturing plant, *each* operation is handled faster and easier because the entire Rex Foundry System was installed to meet the specific problems of the foundry. Picture shows part of the system where a Rex Outboard, Leak-Proof, Apron Conveyor is receiving sand from the shakeouts above, and returning it to the conditioning unit.



③ **LEAKAGE** and spillage are virtually eliminated with these specially designed heavy-duty steel aprons. A cut-away view of the Rex Leak-Proof Apron Conveyor illustrates the equalizing saddle and outboard roller construction. Note how the carrying load is applied only at the center line of each chain to avoid eccentric loads. Note also, the welded pan, designed for fine, free-running materials that have a tendency to leak through the ordinary pan construction.

The Rex staff of factory-trained engineers are always at your service—to help you design and install the best "work-flow" plan possible. Write for complete information, including Bulletin No. 370. Chain Belt Company, 1725 W. Bruce Street, Milwaukee 4, Wisconsin.

REX FOUNDRY HANDLING SYSTEMS

CHAIN BELT COMPANY OF MILWAUKEE

Rex Chain Belt and Transmission Division, Rex Conveyor and Process Equipment Division, Milwaukee 4, Wisconsin • Baldwin-Duckworth Division, Springfield 2, Massachusetts

WHITING Engineered

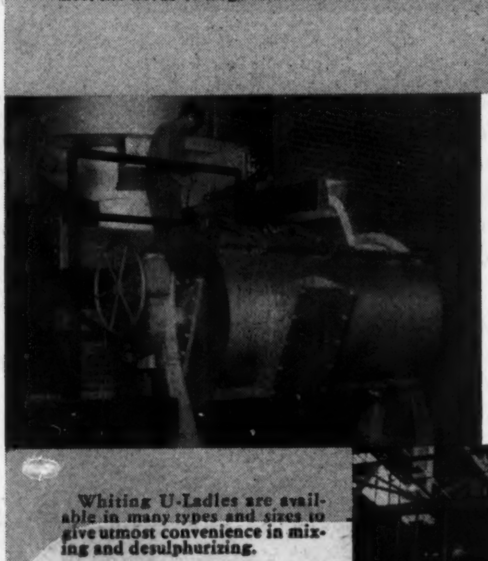
Whiting mechanical cupola charging equipment is available in a wide variety of types to meet the needs of large and small foundries.

Over 90% of the gray iron castings in the U. S. are poured with metal from Whiting Cupolas.

Hydro-Clone Cupola Spark Suppressors lower insurance rates by suppressing sparks with water.

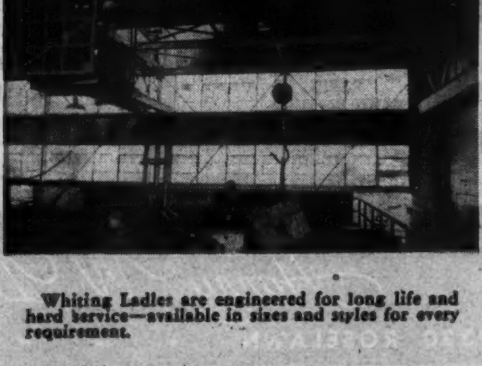
Send for literature fully describing any of the following units of foundry equipment in which you are specially interested.

Cupolas and Cupola Chargers
Cupola Blowers and Accessories
Hot Blast Equipment
Moisture Control Systems
Hydro-Arc Electric Furnaces
Air Furnaces
Rotary Furnaces
Cradle Furnaces
Side-Blow Steel Converters
Coal Pulverizers
Pulverized Coal Firing Equipment
Overhead Traveling Cranes
Duplexing Equipment
Transfer Cars and Trucks
Desulphurizing U-Ladles
Ladles and Ladle Handlers
Tumbling Mills
Hydro-Blast Barrels
Annealing Ovens
Hydro-Clone Dust and Spark Suppressors

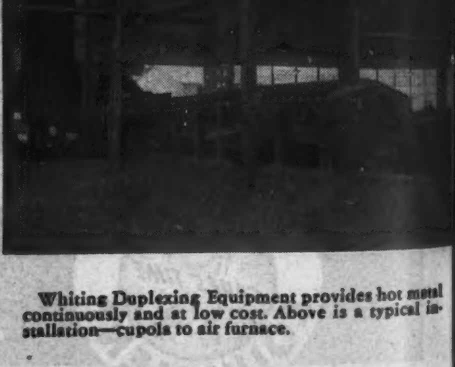


Whiting U-Ladles are available in many types and sizes to give utmost convenience in mixing and desulphurizing.

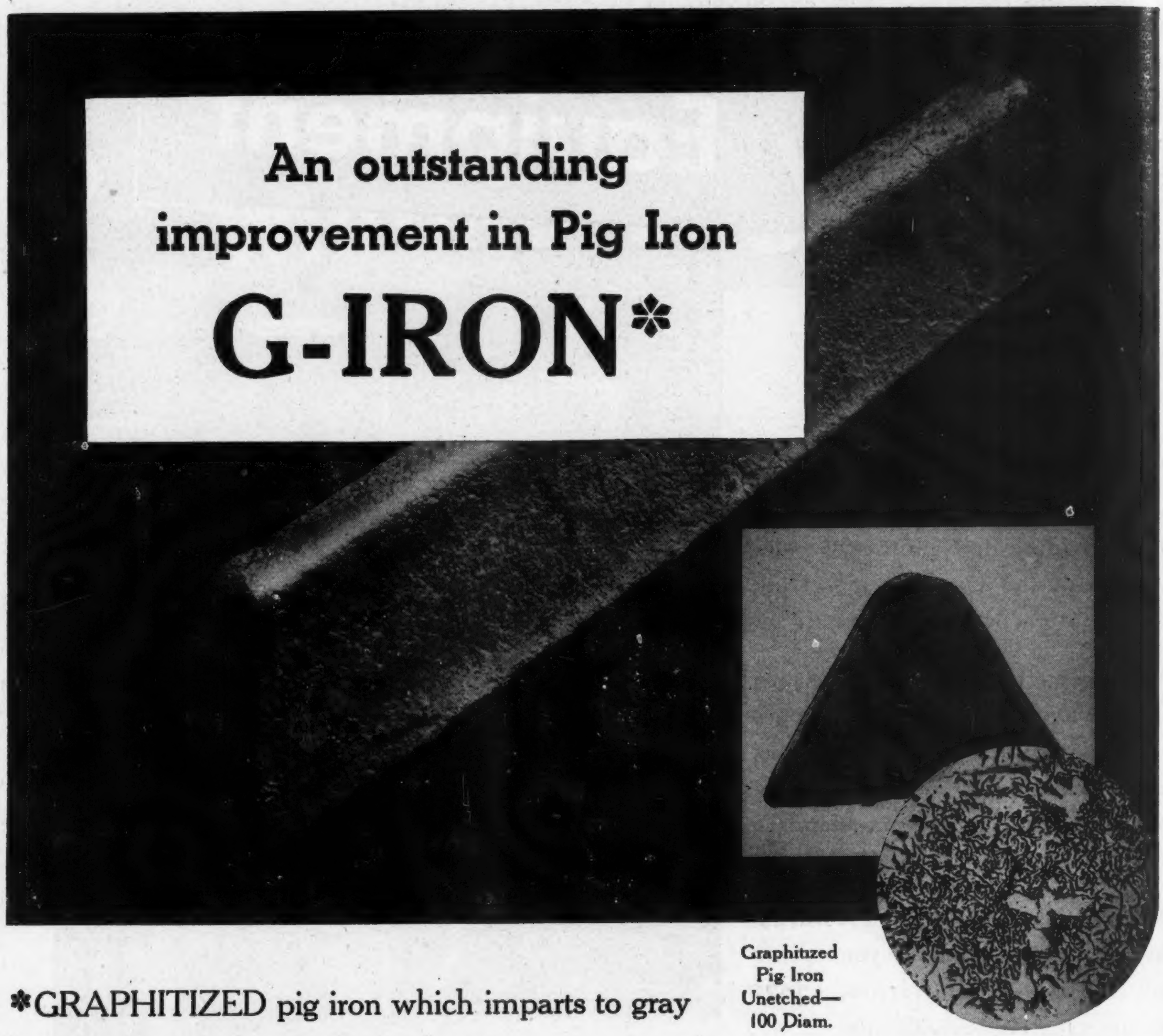
MANUFACTURER'S ASSOCIATION, INC. FOUNDRY EQUIPMENT



Whiting Ladles are engineered for long life and hard service—available in sizes and styles for every requirement.



Whiting Duplexing Equipment provides hot metal continuously and at low cost. Above is a typical installation—cupola to air furnace.



Graphitized
Pig Iron
Unetched—
100 Diam.

*GRAPHITIZED pig iron which imparts to gray iron castings an improvement in—

Regular
Pig Iron
Unetched—
100 Diam.

GRAIN REFINEMENT
MACHINEABILITY
FLUIDITY
SHRINKAGE

TONAWANDA IRON CORPORATION

NORTH TONAWANDA, N. Y.

Division of AMERICAN RADIATOR & Standard Sanitary CORPORATION

**Manufactured under United States and Canadian Patents*

DOUBLE SPEED SMOOTH AND EASY with DoALL Zephyr

CUTTING NON-FERROUS METALS PLASTICS, RUBBER, WOOD . . . .

Here's a machine every operator likes. Its performance is an attention holder every minute. Its speed is a real challenge— there's no waiting for the Zephyr to catch up. It travels just as fast as he cares to make it go, up to 12,000 r.p.m.

The 3,300 pounds of weight make the DoALL Zephyr practically vibrationless when cutting the tough new metals, alloys and laminates used today for war production and in the future for civilian needs.

Your output can be doubled without extra effort. It's just a matter of increasing the speed and guiding the work.

Want to see it work? Phone your DoALL man for a demonstration in your own plant, or write us.

Angle Cutting

Because of the 36" throat and tilting worktable, true angles are cut in 20% to 50% less time than by cut-off methods.

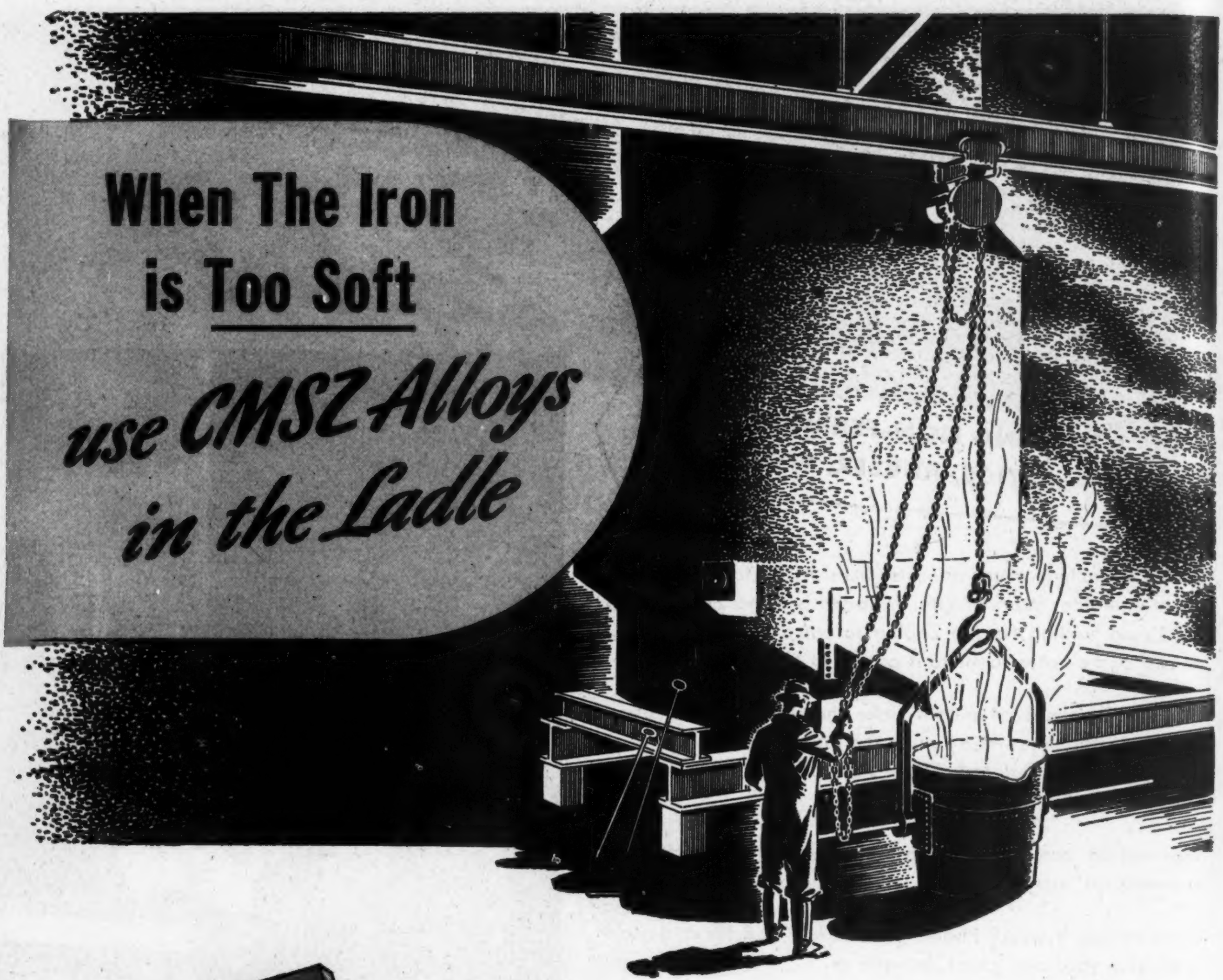
Send for Circular

Learn something about the remarkable performance of the DoALL Zephyr from our latest illustrated circular.

DoALL

INDUSTRY'S NEW SET OF TOOLS

CONTINENTAL MACHINES, INC.
1340 S. Washington Avenue • Minneapolis 4, Minn.



With CMSZ Alloys, you get the advantages of a chromium addition without sacrificing machinability, because CMSZ Alloys contain graphitizing elements as well as chromium.

The iron will be harder...stronger...have better resistance to wear and heat...and with most irons there will be no increase in chill.

For further information on how to use CMSZ Alloys, send the coupon for the booklet "CMSZ Alloys for Ladle Additions of Chromium to Cast Iron."

Buy United States War Bonds and Stamps

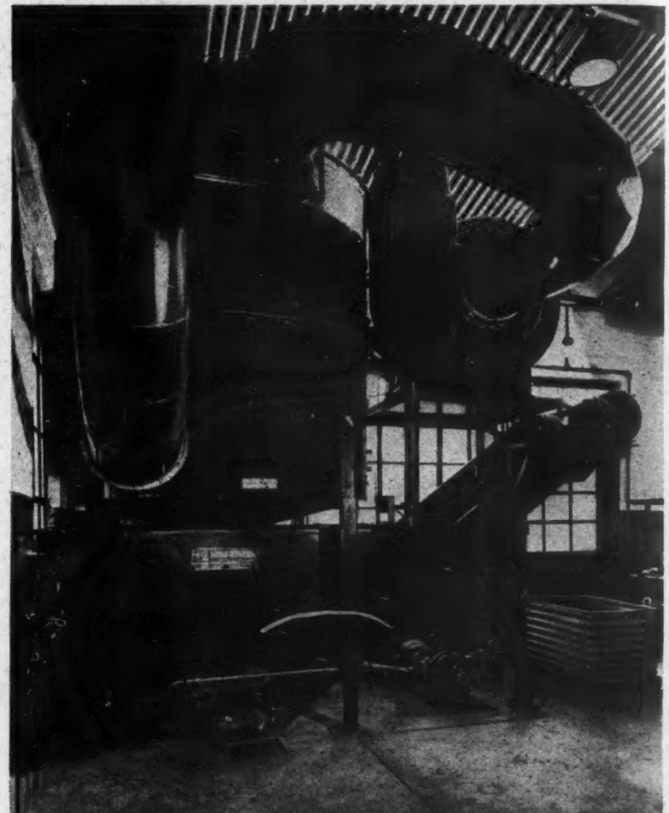
ELECTRO METALLURGICAL COMPANY

Unit of Union Carbide and Carbon Corporation

30 East 42nd Street, New York 17, N. Y.

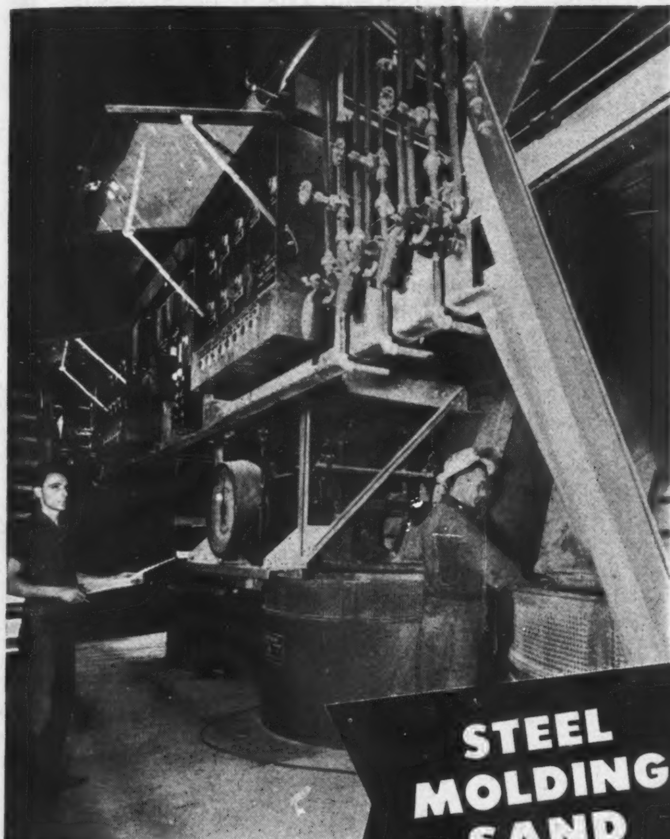
ELECTROMET Ferro-Alloys and Metals are sold by Electro Metallurgical Sales Corporation, and Electro Metallurgical Company of Canada, Limited, Welland, Ontario


ECLIPSE OF THE RISING SUN!
The day has come! The skies are black over Tokyo—black with American bombers—bombers that will blast the Jap sun out of the heavens and off the face of the globe.
Helping to bring this hour of triumph ever closer are the ten plants of Federated Metals supplying vast quantities of aluminum, brass, bronze, die-cast alloys, solder, babbitt and zinc dust to the manufacturers of the "sinews of war."
Wartime production has increased the use of non-ferrous metals. Federated has kept pace with this development by producing alloys of superb quality. The improved technique gained in producing for war is your guarantee of continuing quality when peace comes.
Federated
METALS DIVISION
FMD
AMERICAN SMELTING & REFINING COMPANY
120 BROADWAY, NEW YORK 5, N. Y.
Nation-wide service with offices in principal cities



SIMPSON *Intensive* MIXERS

. . . better sand preparation for *Every* foundry application . . .



STEEL MOLDING SAND

The high density factor of steel and the high pouring temperature, require highly refractory sand mixtures with extreme toughness to resist distortion and metal penetration.

By its smearing, mulling action, the Simpson Mixer assures an even, thin spreading of bonding material on every sand grain—which produces the core and mold surface needed to efficiently produce fine steel castings.

Today, ninety percent of the steel foundries use mulled sand, and approximately eighty percent of this mulled sand is prepared exclusively in Simpson Mixers.

In many plants Simpson Mixers are used as part of a continuous sand preparation plant which serves the entire foundry. The continued and repeated mulling of all the sand in the system is not only desirable for best results, but in many instances, it makes it possible to reduce, and, in some cases, eliminate the use of special facing sands.

If you don't use Simpson Mixers in your plant—if you don't know the Simpson story, write—ask to have a National Engineer tell you all about it.

(ABOVE)
Battery of three No. 3 Unit Drive Simpson Mixers in system of large Pacific coast steel foundry. Note that mixers are completely controlled by National TimeMasters and loaded by means of a traveling batch hopper.

(RIGHT)
No. 1½ Unit Drive Simpson Mixer, National Loader and Aerator on special steel facing sand for intricate work requiring smooth-surfaced and sharp-edged castings.

FOUNDRY EQUIPMENT MANUFACTURER'S ASSOCIATION, INC.

ARMY E NAVY

And now—a second white star has been added to our Army-Navy Production Award Flag—for continued production achievement.

NATIONAL ENGINEERING COMPANY

MACHINERY HALL BUILDING • CHICAGO 6, ILLINOIS

Manufacturers and Selling Agents for Continental European Countries—The George Fischer Steel & Iron Works, Schaffhausen, Switzerland. For the British Possessions, Excluding Canada and Australia—August's Limited, Halifax, England. For Canada—Dominion Engineering Co., Ltd., Montreal, Canada. For Australia and New Zealand—Gibson, Battle & Co., Pty., Ltd. Sydney, Australia

…EVERY FOUNDRY DUST

ROTO-CLONE DUST CONTROL IDEAL FOR SWING FRAME GRINDERS

Swing frame grinder dust control is easily accomplished with the construction of booths exhausted by Type D Roto-Clone. Illustrated at the right are three typical Roto-Clone set-ups showing a variety of booth enclosures tailor-made to specific conditions and types of grinding. By confining dust within booths, dispersion to the work room of all dust particles is prevented at economical cost of dust collector and exhaust volume. Send for Roto-Clone Bulletin No. 272.

SAFE, POSITIVE CONTROL OF MAGNESIUM DUST

The Type N Roto-Clone was designed to meet specific requirements of magnesium dust control and it is also ideally suited to all buffing operations. Its distinguishing features are the elimination of all restrictions, ledges or recesses where dust could be deposited and the precipitation of the dust under water, one of the proven-safe methods of storing this material. Send for Bulletin No. 277.

ing and abrasive cleaning. *Type D,* dry dynamic precipitator for grinding, snagging, portable and swing frame grinders. *Type N,* hydro-static precipitator especially designed for the complete control of magnesium dusts and buffing operations. Bulletins and data sheets describing the use of the Roto-Clone are available on request. For convenience use the coupon.

AAF

AMERICAN AIR FILTER CO., Inc.
104 Central Ave., Louisville [illegible], Ky.

Gentlemen: Please send me data on the following Roto-Clone applications.

____

____

Name____________________________

Company_________________________

Address__________________________

THE "AMERICAN FOUNDRYMAN"

and the 1945

EMERGENCY PROGRAM OF A.F.A.

THIS issue of your "AMERICAN FOUNDRYMAN" begins the publication of those valuable papers and reports originally intended for presentation and discussion at the 1945 Foundry Congress and 49th Annual Meeting of the American Foundrymen's Association. It begins, too, the staging of a "Year-Round Foundry Congress" in lieu of the Detroit convention, the cancellation of which was necessitated by urgent demands on wartime transportation.

Throughout the balance of this year, A.F.A. will bring to its members in this monthly magazine a constant flow of technical and practical information on all phases of foundry practice, with editorial material supplemented by the advertising of manufacturers and suppliers of equipment and materials for foundry use. Thus, for the first time, your "AMERICAN FOUNDRYMAN," in size and content, becomes a full-fledged member of the industrial press.

In editorial policy, the fundamental objectives of A.F.A. as a technical society representing all branches of the foundry industry, will be maintained. Every effort will be made to retain the fair and impartial policy that has characterized the activities of your Association for the past half century. As in the case of papers submitted for the annual meetings, articles offered for publication in "AMERICAN FOUNDRYMAN" will first be passed upon by Committees on Program and Papers, and judged on their merits for what they contribute to the foundry literature.

The reaction of A.F.A. members to announcement of their Association's emergency program of activities for 1945 has met with almost unanimous approval. Typical are the following comments:

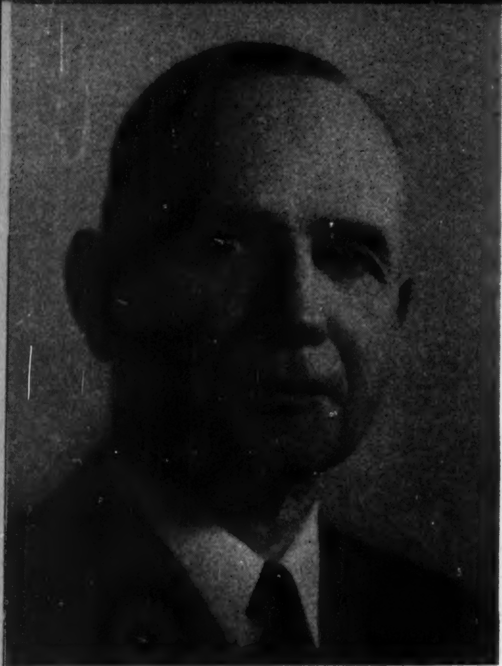
> *"We feel that you have outlined a very constructive program in lieu of the Detroit meeting."*
>
> *"I think our officers are to be congratulated on the program they have formulated for the coming year, to supplement the yearly convention."*
>
> *"I wholeheartedly endorse the program our officers have worked out, which I know will meet with every success."*

Because this is *your* magazine, your comments on the new form in which the "AMERICAN FOUNDRYMAN" now appears are welcomed. Such comments will make possible the presentation of a publication that will *serve the membership* to a maximum degree.

All members are invited to send in to the Chicago office, for publication in "AMERICAN FOUNDRYMAN" and the annual Bound Volume, written discussion on any of the published papers. Discussion materially enhances the value of such papers to the industry. Provision also is being made for authors to present their papers at Chapter meetings this Fall, thus giving further opportunity for discussion.

Foundrymen are invited to submit, for possible publication in "AMERICAN FOUNDRYMAN," worthwhile articles dealing with castings production and processing.

EDITORIAL.



Message to Members from Pre
Inaugurates
"YEAR-'ROUND FOUNDRY C

IT HAS long been a prerogative of the President of the American Foundrymen's Asssociation to express, at the annual convention of the Association, his appreciation for the confidence reposed in him and fine cooperation given him by the membership. That privilege must be foregone this year, since urgent wartime demands on transportation unfortunately made it impracticable to hold the 1945 annual convention in Detroit.

However, this issue of "AMERICAN FOUNDRYMAN" inaugurates an emergency program of A.F.A. activities, adopted in lieu of the Detroit meeting, the importance of which may not be discounted. Instead of an annual foundry congress, A.F.A. here begins the staging of a "Year-'Round Foundry Congress" in paper form, presenting monthly in the "AMERICAN FOUNDRYMAN" those valuable papers and reports originally intended for presentation at Detroit.

Industry More Progress Conscious

Indeed, this undertaking may well mark the beginning of a new era of A.F.A. service to the industry. It is likely to bring into sharper focus the importance of cooperative effort within the industry, and to demonstrate more continuously than ever before the great potential value of that effort when fully recognized by foundry heads.

During the past 49 years these annual meetings of A.F.A. have been a primary factor in promoting continuous progress in our industry. They have brought together from all over the United States and Canada, and from many foreign countries, men willing to give to others some of what they have learned through hard and long experience, that they in turn might learn more. This insatiable desire and determination to improve is the keystone of all industrial progress.

To me it has been an amazing and enlightening experience, during the time I have been privileged to serve as a national officer of A.F.A., to have presided over a constant demonstration of what may be called "cooperation in action." Outstanding among my impressions has been the widespread and wholehearted acceptance of A.F.A. as the common meeting ground for men representing every phase of metal casting.

I have seen foundrymen, the strongest of commercial competitors, jointly discussing in open meeting what once were guarded jealously as "trade secrets." I have seen older men give much valuable time and wisdom to younger men, new in the foundry industry and total strangers, simply because of their common membership in this Association.

Within my own experience I have known many foundry plants whose doors, once closed to outsiders, have cordially opened many times to the password of: *"I am an A.F.A. member."* Undoubtedly it is this same spirit that led the men who were preparing papers for the 1945 convention to carry on in spite of its cancellation, so that their findings might be published to the industry in the "AMERICAN FOUNDRYMAN." The entire industry owes these men a great debt of thanks and appreciation.

All Members Will Benefit

Yes, this industry of ours has come a long way during the past half century in learning the value of cooperation in the solution of many perplexing problems. Many more remain, however, and the difficulty of their solution may well be compounded during the reconversion and readjustments of the post-war period.

It is in the years just ahead, I believe, that A.F.A. will attain its full stature in Service to the Industry, and every A.F.A. member will benefit immeasurably as a result. Nor can this be discounted by any foundry executive as mere hopeful thinking, for during the past year your Board of Directors has taken sound, positive action to help bring this about.

The Technical Development Program, for example, was established last year to insure closer coordination of all technical activities of your Association. Under the guidance of an Advisory Committee composed of men of broad experience and proven business judgment, the Technical Development Program can be expected to fulfill, in even greater measure than in the past, the basic functions and purposes of A.F.A. as a technical society.

An Investment for Foundries

It is the purpose of this important activity, as its name implies, to develop technical and practical information on all phases of castings production, under a long-range

President R. J. Teetor

CONGRESS" for 1945

program that will assure each type of cast metal impartial and fair consideration.

Foundry executives throughout the industry now are being given the opportunity to invest in the future of the Technical Development Program . . . to invest, indeed, in the advancement of their industry.

As a foundry executive myself, it seems to me only good judgment that financial support of this activity should be considered in the light of an investment, and not as a contribution. We who support the valuable work of the various foundry trade associations expect that their activities should be confined to their respective trade interests. Yet all of us realize that wider use of the specific metals we cast depends largely on broader acceptance of all cast metals by the engineers who design industrial products.

Predicts Goal Will Be Met

The one organization in our industry that can and must accomplish this end for all cast structures is A.F.A., through its Technical Department Program. The generous response from many companies, both large and small, indicates that there is a strong realization of this fact, and I feel confident that the initial working-fund goal of $250,000 will be oversubscribed in 1945. Beyond that goal, your A.F.A. Board has taken steps during the past year to maintain this working fund continuously intact.

It would be well if every member of A.F.A. would take the time to read carefully the article in the April issue of "AMERICAN FOUNDRYMAN" pertaining to the new dues structure effective July 1. Especially recommended is a study of the Association's objectives as listed in that article, for the accomplishing of which a Company member will be asked to pay annual dues of *less than 14 cents a day!*

Foundries Must Seek Men

There can be no thinking foundry executive today, after four years of the most intensive production we have ever known under most trying conditions, who is not profoundly concerned with the problem of the foundries' post-war personnel. We are going to have to compete with every other industry for the services of some 11,000,000 men now under arms, for the youths now in grade and high schools, and for the men who once more will seek engineering education in the colleges and universities.

In the past we have normally received a fairly adequate share of the available new blood, but our post-war problem is complicated by several factors. It is only natural to expect that new products and processes will be aggressively publicized and "glamorized," and that many promising young men will be attracted away from such a basic and old-established occupation as the casting of metals in molds. Nor will the many uninformed and adverse statements of the past few years, relative to the foundry as a place to work, help the situation.

More Trained Engineers Needed

We are indeed fortunate in the caliber and number of engineering-trained men who now are leaders in the castings industry. Much of our progress in the past 25 years is due to their mechanical ingenuity, their constant searches for new methods and better quality, and their willingness to impart their knowledge to others. It is widely recognized, however, that the foundry industry will have to go into the engineering schools and colleges in open competition for their graduates, if we are to guarantee a continuing supply of trained men.

For A.F.A. to do this job, three conditions must be met. First, it must be well supported; second, it must be soundly financed; and third, it should have some regular means of keeping the industry informed. Every member of A.F.A. should know that, with continued cooperation by the industry, the way now lies open for your Association to do the job.

Today the membership of A.F.A. stands at well over 7600 . . . the first time in the history of our industry that so many foundrymen have banded together in any common cause. It is a source of deep pride to have served as your President during the year of this accomplishment.

Strength of A.F.A. Assured

Financial actions taken by your Directors during the past year were carefully evaluated in terms of maximum A.F.A. service in the years ahead. There is reason to believe that these actions will prove to have been soundly and wisely taken, and that the industry as a whole will greatly benefit.

Commencing with this issue, the "AMERICAN FOUNDRYMAN" assumes new importance, and new obligations for keeping the industry informed. The form in which the magazine now appears has long been advocated by the membership, and your Directors are confident that it will be well received. It signalizes a new milestone of service to the foundrymen of America, and to those who have so well supplied materials, equipment and services to this great and basic industry.

Ralph J Teetor

President,
AMERICAN FOUNDRYMEN'S ASSOCIATION

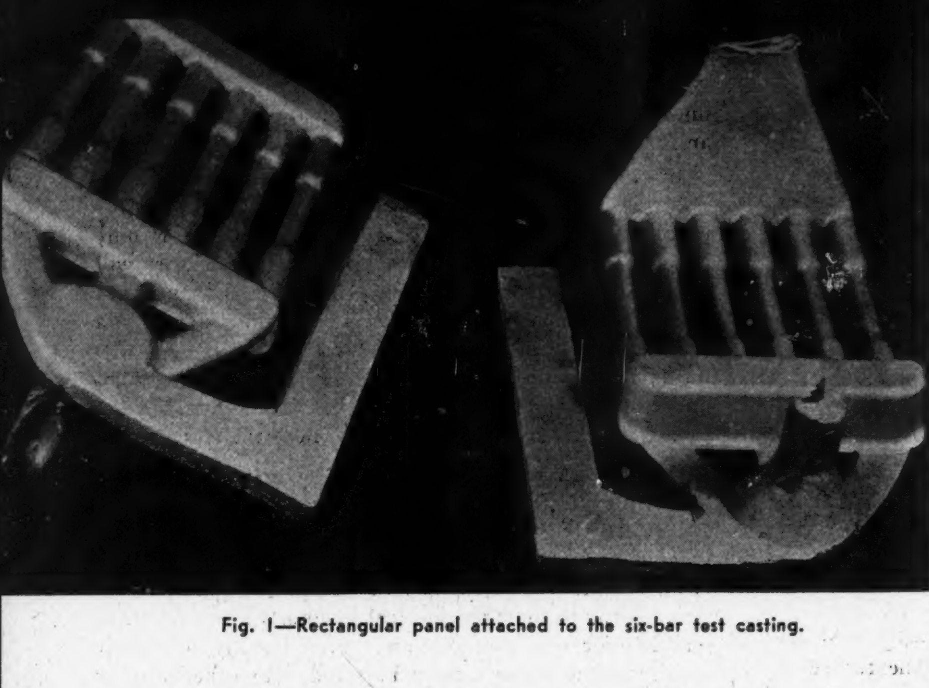


Fig. 1—Rectangular panel attached to the six-bar test casting.

Effect of Gas on the Properties of MAGNESIUM *Sand Casting Alloys*

By R. S. Busk and R. F. Marande,
Metallurgical Dept., The Dow Chemical Co., Midland, Mich.,
and W. C. Newhams, Metallurgical Dept., Bay City, Mich. Div.

THE problem of gas in magnesium has not been generally recognized since the pinhole type of porosity found in other metals rarely occurs. The possible existence and the effects of microshrinkage in magnesium castings have been known for some time. Investigation has shown that gas will produce an appearance substantially the same as microshrinkage.

During numerous experiments the observation was made that the severity of microporosity is proportional to exposure to moisture. Also, dry hydrogen gas bubbled through a molten magnesium alloy will produce all stages of porosity from a gradual increase in microporosity to hot tears and bubbles.

Many Tests Made

Many tests have been made to find suitable methods of removing the effects of gases, and particularly hydrogen, in metals. In general, two methods have proved to be successful[1,2,3]; (1) lowering the partial pressure as by standing or bubbling a gas insoluble in the metal, and (2) introducing an agent that reacts with the hydrogen in such a way as to remove it. An effective method of removing hydrogen by lowering the partial pressure only is by bubbling an inert gas, e.g., helium, through the molten metal. However, chlorine is more effective because it not only reduces the partial pressure but also combines with the hydrogen.

Work on Two Alloys

All of the work reported in this paper is confined to two alloys, compositions of which are given in Table 1.

It was necessary to develop a numerical system of measuring the degree of porosity characteristic of a given melt. A series of shapes was tried, including a wedge, a cone and several types of rectangular and triangular panels. One rectangular and one triangular panel were finally selected, as shown in Figs. 1, 2, 3 and 4. The rectangular panel is so designed that there always will be porosity in the end farthest from the gate, with the commercial alloys studied. As the porosity tendency of the alloy increases for any reason, the porosity will progress toward the gate until it permeates the whole panel. Thus the amount of space left free of porosity is a measure of the soundness of the alloy. This panel is suitable for studying low porosity alloys, such as "C" alloy.

Triangular Panel Porosity Free

The triangular panel was developed specifically for "H" alloy and normally is porosity free. As gas is introduced or picked up, porosity will begin to appear at the gate or base end of the triangle and progress toward the apex. Thus the length of porosity-free space in inches from the apex toward the gate end is a measure of the soundness of the melt. The appearance and rating system of porosity in the triangular panel is illustrated in Figs. 5 to 10 inclusive.

The effect of pouring temperature and the consistency of the results with the triangular panel are illustrated in Table 2. The figures shown represent an average of the ratings obtained on four panels poured at each temperature. The ratings were consistent to plus or minus ½ in. at each temperature. From 1300 to 1600° F. the average ratings agreed to within plus or minus one inch. All panels discussed in this paper were poured at 1400° F., and a difference of one inch is considered significant.

Test bars usually are sound, but if appreciable gas is present porosity may appear. At such times the test

Table 1

COMPOSITIONS AND HEAT TREATMENTS OF ALLOYS

	Composition, per cent					Typical Heat Treated Tensile Properties		
Alloy	*Al*	*Zn*	*Mn*	*Mg*	*Heat Treatment*	*Elongation, per cent in 2 in.*	*Yield Strength, psi.*	*Tensile Strength, psi.*
C	8.3-9.7	1.7-2.3	0.10	Rem.	2 hr. from 500° F. to 770° F. + 16 hr. at 770° F.	10	16,000	40,000
H	5.3-6.7	2.5-3.5	0.15	Rem.	2 hr. from 500° F. to 730° F. + 10 hr. at 730° F.	12	14,000	40,000

bar itself may be used as a measure of the amount of gas present. As shown in Fig. 1, a 6-bar test bar pattern was used instead of the conventional 4-bar type. The former was chosen because this 6-bar pattern is more sensitive to porosity than the latter.

Experimental Data

The apparatus used for introducing the various gases is shown in Fig. 11. This assembly was developed specifically for introducing chlorine and consists of the gas cylinder and pressure gauge, a rubber tube, an iron tube and, finally, a graphite tube leading into the metal. A plain steel pipe would have sufficed for all gases except chlorine, but, to avoid changing, this apparatus was used throughout. Tensile properties were determined on ½-in. diameter bars without machining. All bars were tested in the solution heat treated state (Table 1). The yield strength is defined as the stress at which there is 0.2 per cent deviation from the modulus line. The elongation is given in per cent in 2 in.

Metallographic examination[4] was made by cutting samples at the fracture from the bars having the highest and the lowest tensile strength in each set of six. The average grain diameter is expressed in inches. The degree of solution obtained during heat treatment is indicated by the compound rating which is zero for complete solution and 10 for as-cast metal. Voids due to microporosity or heat treatment (burning) are rated on a scale which is similar to that used for compound.

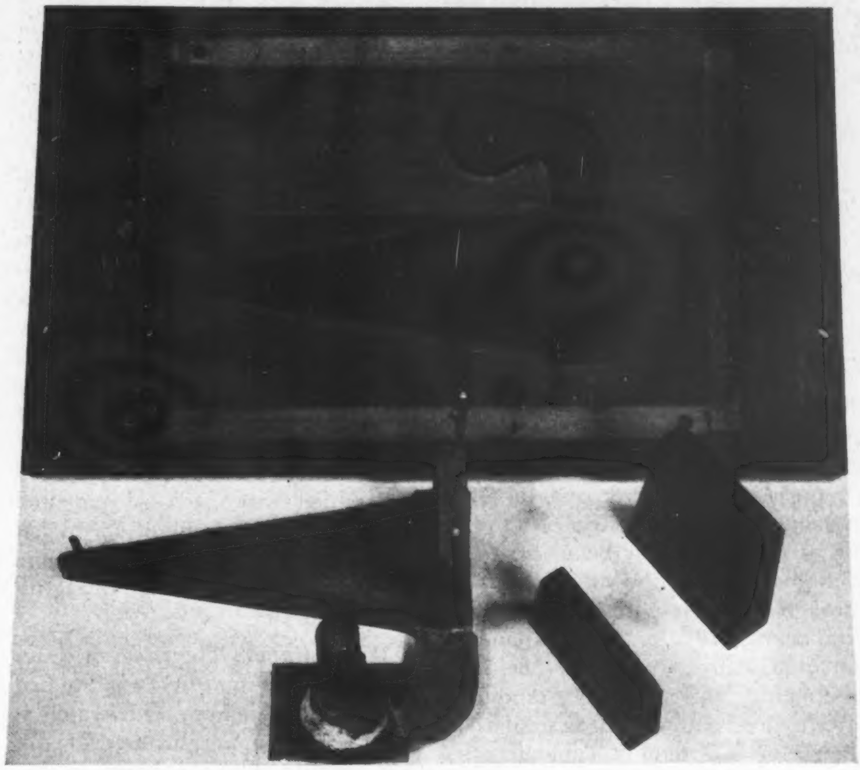


Fig. 2—Triangular panel.

Laboratory Tests

Preliminary experiments in which various gases were bubbled through molten magnesium alloys showed that only hydrogen and water vapor caused the extreme type of porosity, evidenced by gas bubbles in the risers. Winterhager[5] also has shown that hydrogen is the major gas constituent in solid magnesium. Therefore, first attention is given to this gas.

Hydrogen: Figure 5 illustrates the appearance of a panel that has been treated with chlorine until substantially free of gas, and Fig. 6 shows

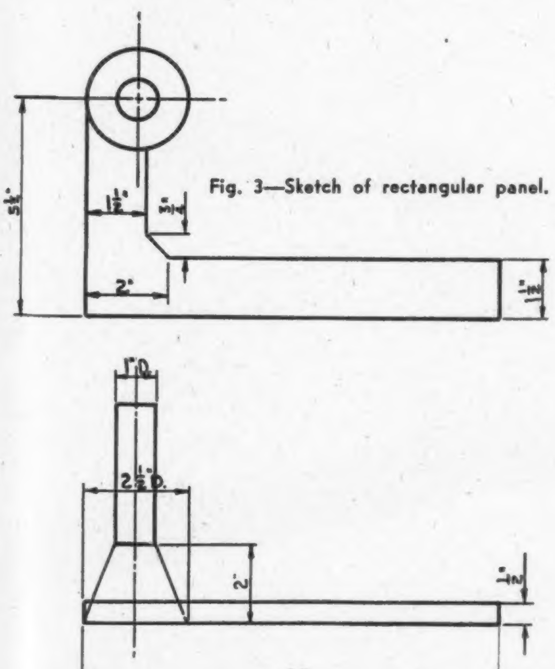


Fig. 3—Sketch of rectangular panel.

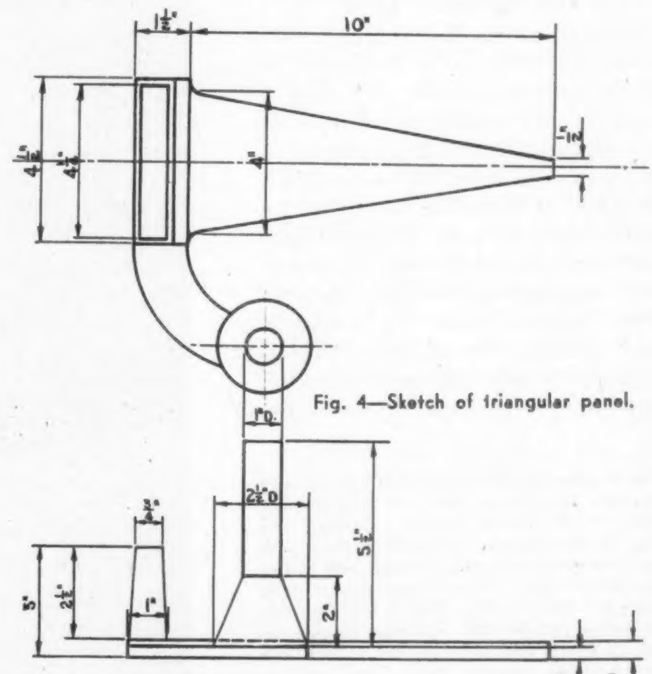


Fig. 4—Sketch of triangular panel.

Table 2
Effect of Pouring Temperature on Porosity Shown by Triangle Panel

(Ingot H Alloy Superheated 15 Min. at 1700° F.)

Pouring Temperature, °F.	*Soundness, Inches*
1200	2¼
1300	6
1350	7¾
1400	7⅜
1450	7⅞
1500	6
1600	6¾

a panel poured from the same melt after gassing with hydrogen for 15 min. at 1550° F. The effect of standing at 1400° F. after being treated with hydrogen is shown in Figs. 7 through 10. The porosity gradually disappears until after 2 hr. the panels are practically as clear as before treatment. This effect of standing after hydrogen treatment is similarly shown for "C" alloy in Table 3.

In each of the remaining experiments on the effects of various gases, 300 lb. of "H" alloy is treated with chlorine for ½ hr. to reduce the gas content to a low and equivalent basis for all tests. The gas being studied was then added, and at periodic intervals about 10 lb. of metal was ladled out to pour panels and test bars. All gases except those deliberately saturated with water vapor were dried by passing them over $CaCl_2$.

Dry Hydrogen Tested

The effect of dry hydrogen followed by chlorine is illustrated in Table 4. The amount of hydrogen used was not measured, but the flow was adjusted so that the agitation of the melt was about the same as for chlorine. It should be noted that the tensile properties are markedly lowered by treatment with hydrogen and subsequently brought back to their original values by treatment with chlorine. The ratings of the triangular panels indicate that the soundness of the metal can be as low as about 4 in. of free space and still produce sound test bars. Thus casting design influences the presence of porosity due to gas as well as that due solely to shrinkage.

The ability of helium to remove hydrogen is illustrated in Table 5. The flow of helium was adjusted in the same manner as that of hydrogen. In 30 min. the helium treatment did not raise the triangular panel rating to 10 nor the properties to their original values. However, if continued for a sufficient length of time, helium will remove all of the gas porosity. This is illustrated by a run which was made on remelted scrap. The soundness of the metal as melted was 3. After a 15-min. treatment with helium the rating increased to 10.

Water Vapor: The effect of water vapor on gas porosity was studied by saturating helium with water at 165° F. The apparatus used for this test consists of a gas meter, a constant temperature water bath, and a hot tube to prevent condensation. The helium was bubbled through two bottles of water in succession, which were maintained at a temperature of 165° F. in the water bath.

The results obtained are tabulated in Table 6. After one cu. ft. of gas had passed through the metal, the soundness was reduced from 10 to 8½. It then went progressively down to a value of 3 after 15 cu. ft. of gas had been bubbled through the melt. Subsequent treatment with 15 cu. ft. of dry helium failed to bring the soundness rating back to its original value.

Mechanical Properties Normal

The mechanical properties remain about normal during the original treatment of the melt with dry helium for 30 min. at 1500° F. (Table 6). The properties decreased as the water vapor was introduced. The properties did not return to their original values upon subsequent treatment with dry helium at 1400° F., principally due to an increase in grain size. This effect is to be expected when a melt is held at a low temperature for this length of time after superheating.

Natural Gas: There sometimes is danger of hydrocarbons coming into

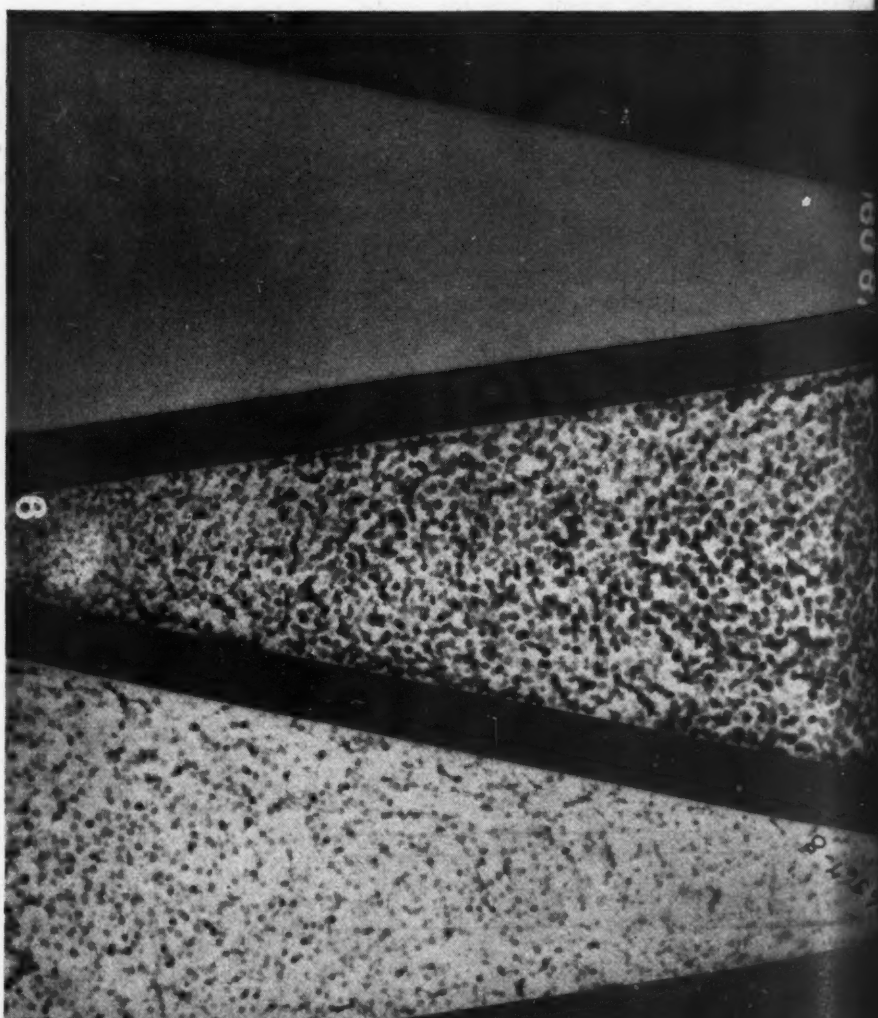


Fig. 5—Radiograph of a panel poured with gas-free magnesium alloy chlorinated with 0.02 lb. Cl_2/lb. of metal. Rating = 10. Fig. 6—Radiograph of panel poured with gas-free magnesium alloy treated with hydrogen for 15 min. Porous areas appear dark. Rating = blow holes. Fig. 7—Radiograph of panel poured with gas-free magnesium alloy treated with hydrogen for 15 min. and let stand for 15 min. Porous areas appear dark. Rating = blows and hot tears.

contact with molten magnesium. The ability of magnesium to crack these compounds and the possibility of subsequent gassing is of interest. There also have been some suggestions that natural gas can be used to refine the grain. Therefore, the effect of natural gas on porosity was investigated. The data in Table 7 show that natural gas used in this way can result in porosity and a resultant loss in tensile strength. Subsequent treatment with chlorine removed the effects of the natural gas after about 10 min.

Effect of Sulphur Dioxide

Sulphur Dioxide: Because SO_2 commonly is used with molten magnesium, knowledge regarding its effect on porosity is important. The data obtained on the effect of SO_2 on porosity are shown in Table 8. If SO_2 has any effect it is not discernible by the rather sensitive triangular panel after 30 min. treatment. No effect was detected by any of the other measurements shown in the table.

Carbon Dioxide: Table 9 shows that carbon dioxide has a slight effect on increasing the porosity and decreasing the mechanical properties. Any detrimental effect is corrected after about 5 min. treatment with chlorine.

Oxygen: The effect of treating "H" alloy with oxygen is shown in Table 10. After 10 min. the metal became so slushy that the molds would not run. At the end of 30 min., test bars were obtained by pouring the metal directly down the sprue. This is in contrast to the usual magnesium foundry practice of pouring into a pouring cup. The increase in porosity shown in the triangular panel may be due to the slushiness and lack of feeding caused by the MgO present rather than from oxygen dissolved in the metal.

The period between the end of the oxygen treatment and the start of the chlorine treatment may have been sufficiently long to settle out some of the MgO and result in an increase in soundness.

Porosity Increased

Nitrogen: Treatment of molten "H" alloy with nitrogen increased the porosity in the triangular panel, as shown in Table 11. The test bar properties were not affected. Subsequent treatment with chlorine removed the effects of the nitrogen within 10 min.

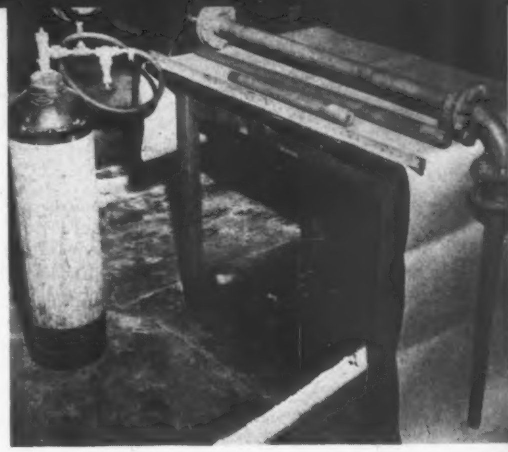


Fig. 11—Apparatus used to introduce gas into molten metal.

Commercial Foundry Tests

Since porosity is a problem in the magnesium foundry, it is desirable to determine to what extent this condition is due to gas. Therefore, a study to discover the sources, and means of prevention and elimination of gas was initiated.

Effect of Condition of Metal Charge on Porosity: A statistical study of test bars was made in the production foundry, relating metal condition to porosity. Table 12 describes the variations of metal treatment studied to determine the effect on gas porosity. The same 6-bar test mold previously described also is used in these experiments. In all except the last test in Table 12, the metal was melted, superheated and poured in a 150 lb. capacity crucible. In the last test the metal was premelted, transferred to the crucible, superheated and poured according to the usual practice[6].

Metal Dried

Metal to be dried was placed in the ordinary steel tote box (about 6 ft. x 3 ft.) and heated in a gas-fired oven in such a way that the contents of the box reached 212° F. in about ½ hr. Therefore, a one hour drying period indicates that

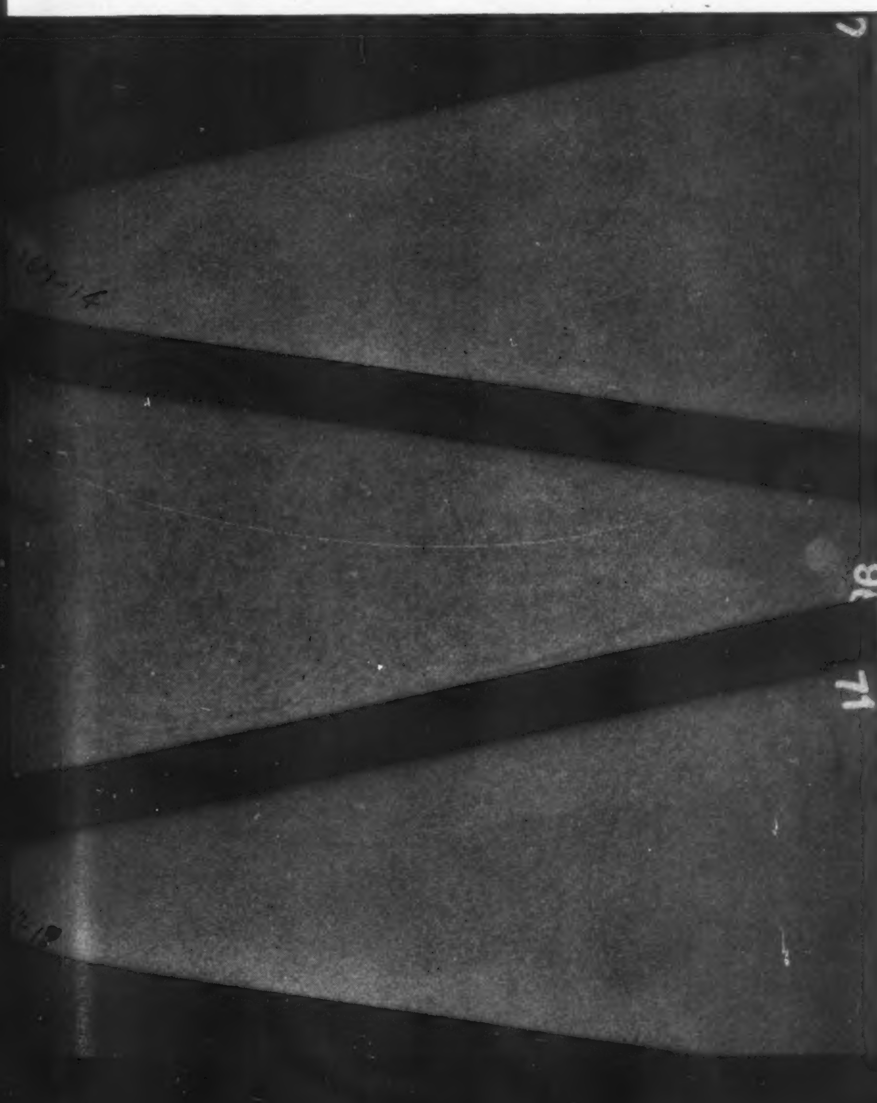


Fig. 8—Radiograph of panel poured with gas-free magnesium alloy treated with hydrogen for 15 min. and let stand for 30 min. Porous areas appear dark. Rating = 0.
Fig. 9—Radiograph of panel poured with gas-free magnesium alloy treated with hydrogen for 15 min. and let stand for 1 hr. Porous areas appear dark. Rating = 4½.
Fig. 10—Radiograph of panel with gas-free magnesium alloy treated with hydrogen for 15 min. and let stand for 2 hr. Porous areas appear dark. Rating = 6½.

Table 3

EFFECT OF STANDING ON H_2 TREATED "C" ALLOY

Time, minutes		Soundness, inches	Heat Treated Tensile Properties: Elongation, per cent in 2 in.	Yield Strength, psi.	Tensile Strength, psi.
Treat H_2	15	Blow Holes	0.9	12,900	15,300
Let stand at 1400° F.	15	Hot Tears	0.7	14,400	16,800
	30	Hot Tears	1.4	16,700	25,700
	120	0	3.0	19,400	34,600
	60	2	4.6	18,800	37,900
	180	4	5.3*	19,800*	40,000

*The relatively low elongation and high yield strength are due to slow cooling after heat treatment, resulting in partial precipitation hardening.

the metal was above 212° F. for at least ½ hr. In Table 12, an entry under "porous" indicates at least one porous test bar from a given mold, while an entry under "sound" means all bars from a given mold were radiographically sound. Since the work on the triangular panel shows that considerable porosity must be evident in the panel before the test bar will be porous, this is in effect a measure of the presence of gas.

The most significant part of this table is the fact that ingot metal melted and cast into test bars produced radiographically sound bars, while riser scrap not dried produced 100 per cent porous bars. It should be noted that the special 6-bar pattern was used, and that this work was done in the summer. Drying the scrap reduced, and premelting markedly reduced the number of porous test bars obtained. Drying at 212° F. will not dissociate $Mg(OH)_2$, but it will be decomposed at melting temperatures with liberation of hydrogen. This may explain the failure to completely eliminate the porous test bars by drying at 212° F.

Effect of Cl_2 on Quality of Commercial Castings: Since the previous section indicates that porosity may be a problem even though scrap is dried or premelted, the effect of removing the gas by chlorinating the metal just before pouring was investigated.

Table 13 shows the effect of chlorination on several types of commercial castings. Open pot melting refers to the operation of melting metal in a large pot and ladling it into the molds. In crucible melting the metal is poured directly from the crucible into the mold[6].

The chlorine used was weighed and tabulated as lb. of Cl_2 per lb. of metal treated. In order to insure adequate degassing, about 0.02 lb.

Table 4

EFFECT OF H_2 ON "H" ALLOY*

Treatment: Time, min.	Gas	Weight of Gas, lb./lb. metal	Soundness: Triangle Panel, inches	Test Bars	Metallography: Compound	Porosity and Burning	Grain Size, in. x 10^{-3}	Heat Treated Tensile Properties: Elongation, per cent in 2 in.	Yield Strength, psi.	Tensile Strength, psi.
0	H_2		10	Sound	<1	2	4½	13.3	13,500	40,300
2	H_2		10	Sound	<1	2	5	12.5	14,000	40,800
5	H_2		8½	Sound	<1	2	4½	14.2	13,700	44,200
10	H_2		3½	Sound	0	3	4	13.2	13,500	40,000
20	H_2		0	Porous	0	5	3½	6.5	13,300	30,800
30	H_2		Hot Tears	Hot Tears	0	4½	4	3.8	12,500	24,000
0	Cl_2	0	¼	Porous	<1	3½	4½	5.4	13,100	27,900
2	Cl_2	0.0016	0	Porous	0	3½	4	6.8	13,000	30,500
5	Cl_2	0.004	1	Porous	<1	3	4½	7.7	13,600	34,500
10	Cl_2	0.009	4¼	Sound	<1	2	4	15.3	14,000	41,800
20	Cl_2	0.0185	10	Sound	<1	1	4	16.3	13,700	41,700
30	Cl_2	0.029	10	Sound	<1	1	3	15.7	14,300	41,900

*Treated with 0.02 lb. Cl_2/lb. metal at 1400° F., superheated 15 min. at 1700° F., gassed at 1500° F., then treated with Cl_2 at 1400° F.

Table 5

EFFECT OF He ON H_2 SATURATED "H" ALLOY*

Treatment: Time, Min.	Gas	Soundness: Triangle Panel, inches	Test Bars	Metallography: Compound	Porosity and Burning	Grain Size, in. x 10^{-3}	Heat Treated Tensile Properties: Elongation, per cent in 2 in.	Yield Strength, psi.	Tensile Strength, psi.
0	H_2	10	Sound	2	2½	5	14.1	13,400	41,100
2	H_2	10	Sound	1½	3	4	13.6	14,300	41,400
5	H_2	5¾	Sound	1½	3	3½	10.2	14,700	36,800
10	H_2	0	Porous	1	3½	3½	6.5	14,200	31,100
20	H_2	Hot Tears	Porous	2	3½	4½	3.1	13,100	21,700
30	H_2	Bubbles	Porous	2	4	5	1.8	11,500	17,600
0	He	Hot Tears	Porous	2	4	6	3.2	11,700	21,000
2	He	Hot Tears	Porous	2	4	5	4.5	12,100	24,800
5	He	0	Porous	2	4	5	5.2	12,900	27,400
10	He	0	Porous	2	3½	5	5.1	13,000	27,900
20	He	3	Porous	2	3½	6	9.0	12,900	34,800
30	He	5¼	Sound	2	3½	7½	11.0	12,900	37,300

*Treated with 0.02 lb. Cl_2/lb. metal, superheated 15 min. at 1700° F., gassed with H_2 at 1500° F., treated with He at 1400° F.

Table 6

EFFECT OF H_2O ON "H" ALLOY*

Treatment: Time, Min.	Treatment: Cu. Ft.	Treatment: Gas	Treatment: Temp., °F.	Soundness: Triangle, inches	Soundness: Test Bars	Metallography: Compound	Metallography: Porosity and Burning	Metallography: Grain Size, in. x 10^{-3}	Heat Treated Tensile Properties: Elongation, per cent in 2 in.	Heat Treated Tensile Properties: Yield Strength, psi.	Heat Treated Tensile Properties: Tensile Strength, psi.
0		Dry He	1500	10	Sound	<1	1	4	14.0	13,600	40,800
2		Dry He	1500	10	Sound	<1	3½	4½	11.5	13,600	38,800
5		Dry He	1500	10	Sound	<1	2½	4	12.7	13,700	39,600
10		Dry He	1500	10	Sound	<1	2	3	11.6	14,500	39,700
20		Dry He	1500	10	Sound	<1	2½	4	12.9	14,500	40,800
30	18	Dry He	1500	10	Sound	<1	4	4	11.7	14,200	39,700
	0	He + H_2O	1500	10	Sound	<1	4	4½	11.3	13,300	38,200
	1	He + H_2O	1500	8½	Sound	<1	4	4	11.7	13,500	38,500
	2	He + H_2O	1500	8	Sound	<1	3	4	11.8	13,500	38,300
	5	He + H_2O	1500	6	Sound	0	2½	5	10.4	12,300	35,300
	10	He + H_2O	1500	4	Sound	0	3½	4	9.5	13,300	36,000
75	15	He + H_2O	1500	3	Porous	0	4	4	9.6	13,500	36,800
0		Dry He	1400	4	Porous	<1	4	5½	9.5	12,300	34,700
2		Dry He	1400	4	Sound	<1	4	5	9.8	12,500	35,800
5		Dry He	1400	4¼	Sound	<1	4	5	9.6	12,300	35,200
10		Dry He	1400	6¼	Sound	<1	4½	5½	9.3	12,500	35,000
20		Dry He	1400	6¼	Sound	<1	4½	6½	10.0	12,100	35,700
30	15	Dry He	1400	8¼	Sound	<1	2½	9	9.0	11,500	34,000

*Treated with 0.02 lb. Cl_2/lb. metal at 1400° F., superheated 15 min. at 1700° F., then treated with 18 cu. ft. of dried He, then with 15 cu. ft. of He saturated with H_2O at 165° F., then with 15 cu. ft. of dried He. Poured at 1400° F.

Table 7

EFFECT OF NATURAL GAS* ON "H" ALLOY†

Treatment: Time, Min.	Treatment: Gas	Treatment: Temp., °F.	Soundness: Triangle, inches	Soundness: Test Bars	Heat Treated Tensile Properties: Elongation, per cent in 2 in.	Heat Treated Tensile Properties: Yield Strength, psi.	Heat Treated Tensile Properties: Tensile Strength, psi.
0	Natural Gas	1500	10	Sound	13.2	14,400	40,800
2	Natural Gas	1500	10	Sound	12.9	14,800	40,400
5	Natural Gas	1500	10	Sound	9.5	14,100	36,400
10	Natural Gas	1500	10	Sound	10.2	14,200	37,400
20	Natural Gas	1500	5	Sound	7.1	14,300	33,800
30	Natural Gas	1500	3¾	Porous	7.9	13,300	33,200
0	Cl_2	1400	4¼	Sound	10.8	14,100	37,900
2	Cl_2	1400	4¾	Sound	8.8	13,800	34,900
5	Cl_2	1400	5½	Sound	9.8	14,400	37,300
10	Cl_2	1400	10	Sound	11.2	13,800	38,200
20	Cl_2	1400	10	Sound	12.4	13,800	39,700
30	Cl_2	1400	10	Sound	14.3	14,200	41,200

*Typical Gas Analysis, per cent: CH_4—77.85; C_2H_6—8.59; N_2—9.31; O_2—0.09; Propane—3.00; Butane—0.77; Pentane—0.26; Hexane—0.13. The gas was dried by passing over $Mg(ClO_4)_2$.

†Treated with 0.02 lb. Cl_2/lb. metal at 1400° F., superheated 15 min. at 1700° F., gassed with natural gas at 1500° F., then treated with Cl_2 at 1400° F.

of chlorine per lb. of metal should be used (Table 4). The effectiveness of the chlorination was measured by radiographing the castings and estimating the tensile strength by the amount of porosity present in the *most porous section*[7]. This method is accurate to within 2000 psi. An estimate of 34,000 psi. indicates no porosity visible in the radiograph.

The improvement after chlorination is evident in all but two cases. In the instances where chlorination did not remove all the porosity, and sufficient Cl_2 was bubbled through (0.02 lb. per lb. of metal), the remainder can be attributed to shrinkage and lack of feeding.

Table 8

EFFECT OF SO_2 ON "H" ALLOY*

Treatment: Time, min.	Treatment: Gas	Wt. of Gas, lb.	Soundness: Triangle Panel, inches	Soundness: Test Bars	Metallography: Compound	Metallography: Porosity and Burning	Metallography: Grain Size, in. x 10^{-3}	Heat Treated Tensile Properties: Elongation, per cent in 2 in	Heat Treated Tensile Properties: Yield Strength, psi.	Heat Treated Tensile Properties: Tensile Strength, psi.
0	SO_2	0	10	Sound	<1	1	4	13.8	14,100	41,200
2	SO_2	0.22	10	Sound	<1	2	4	13.1	13,700	40,700
5	SO_2	0.54	10	Sound	<1	1½	4.5	14.2	14,500	41,300
10	SO_2	1.1	10	Sound	<1	1	3	15.4	14,900	42,400
20	SO_2	2.2	10	Sound	<1	1	3.5	11.8	14,900	40,200
30	SO_2	3.25	10	Sound	1	1	4	12.2	14,200	39,500
0	Cl_2	0	10	Sound	1	1	4	16.5	14,300	42,500
2	Cl_2	0.38	10	Sound	<1	1	4	16.2	14,000	41,500
5	Cl_2	0.96	10	Sound	1	1	4	15.6	14,300	42,200
10	Cl_2	1.9	10	Sound	1	<1	4	14.6	14,200	42,100
20	Cl_2	3.8	10	Sound	<1	1	4	13.3	13,800	41,000
30	Cl_2	5.75	10	Sound	1	1	4	13.7	14,300	41,300

*Treated with 0.02 lb. Cl_2/lb. metal at 1400° F., superheated 15 min. at 1700° F., gassed at 1500° F., then treated with Cl_2 at 1400° F. 300-lb. melt.

Table 9

EFFECT OF CO_2 ON "H" ALLOY*

Treatment			Soundness		Metallography			Heat Treated Tensile Properties		
Time, min.	*Gas*	*Wt. of Gas, lb.*	*Triangle Panel, inches*	*Test Bars*	*Compound*	*Porosity and Burning*	*Grain Size, in. x 10^{-3}*	*Elongation, per cent in 2 in.*	*Yield Strength, psi.*	*Tensile Strength, psi.*
0	CO_2	0	10	Sound	3½	2	5	12.7	14,200	41,000
2	CO_2	0.17	10	Sound	2½	1	5	12.8	14,500	40,400
5	CO_2	0.42	10	Sound	2	1	5	11.8	15,000	40,100
10	CO_2	0.84	10	Sound	2	2	5	12.1	14,500	41,300
16	CO_2	1.3	10	Sound	2½	1½	5	11.3	14,100	39,800
30	CO_2	2.5	7½	Sound	2	2	4½	11.2	14,200	39,300
0	Cl_2	0	7	Sound	2	2	4½	14.4	14,300	41,600
2	Cl_2	0.38	10	Sound	2	2½	4½	....	....	....
5	Cl_2	0.96	10	Sound	1½	1	4	15.0	14,500	41,100
10	Cl_2	1.9	10	Sound	1	1	6	14.7	14,200	41,400
20	Cl_2	3.8	....	Sound	2	2	6	10.3	14,400	38,600
30	Cl_2	5.75	10	Sound	1½	1	5	14.4	14,200	40,600

*Treated with 0.02 lb. Cl_2/lb. metal at 1400° F., superheated 15 min. at 1700° F., gassed at 1500° F., then treated with Cl_2 at 1400° F. 300-lb. melt.

Table 10

EFFECT OF O_2 ON "H" ALLOY†

Treatment			Soundness		Metallography			Heat Treated Tensile Properties		
Time, min.	*Gas*	*Wt. of Gas, lb.*	*Triangle Panel, inches*	*Test Bars*	*Compound*	*Porosity and Burning*	*Grain Size, in. x 10^{-3}*	*Elongation, per cent in 2 in.*	*Yield Strength, psi.*	*Tensile Strength, psi.*
0	O_2	0.0	10	Sound	2½	1	4	13.0	13,800	39,700
2	O_2	0.22	10	Sound	1	1	4½	12.6	14,100	40,100
5	O_2	0.54	10	4 bars porous	1	2	4½	7.2	14,200	34,000
10	O_2	1.1	8¼	Sound	....*	....	....	....	....	....
20	O_2	2.2	9¼	Sound	....	....	....	....	....	....
30	O_2	3.25	6¼	2 bars porous	1	1	4	11.9	14,500	40,200
0	Cl_2	0	10	Sound	½	½	3½	14.8	14,500	42,300
2	Cl_2	0.38	8¾	Sound	1	1	4	13.7	14,100	41,100
5	Cl_2	0.96	10	Sound	1	1	4	16.3	13,800	42,300
10	Cl_2	1.9	10	Sound	½	1	4	14.8	14,100	41,300
20	Cl_2	3.8	10	Sound	3	½	7	13.3	13,800	39,800
30	Cl_2	5.75	10	Sound	1	1	4½	14.8	13,800	41,200

†Treated with 0.02 lb. Cl_2/lb. metal at 1400° F., superheated 15 min. at 1700° F., gassed at 1500° F., then treated with Cl_2 at 1400° F. 300-lb. melt.
*The addition of O_2 made it difficult to fill the mold. After 10 minutes and 20 minutes the test bar mold did not fill at all. After 30 minutes the mold was filled by pouring directly down the sprue.

Table 11

EFFECT OF N_2 ON "H" ALLOY*

Treatment			Soundness		Metallography			Heat Treated Tensile Properties		
Time, min.	*Gas*	*Wt. of Gas, lb.*	*Triangle Panel, inches*	*Test Bars*	*Compound*	*Porosity and Burning*	*Grain Size, in. x 10^{-3}*	*Elongation, per cent in 2 in.*	*Yield Strength, psi.*	*Tensile Strength, psi.*
0	N_2		10	Sound	2½	2½	4	14.0	14,300	41,200
2	N_2		10	Sound	2	2	4	14.8	14,000	41,200
5	N_2		10	Sound	2½	2½	4½	13.4	14,200	41,300
10	N_2		10	Sound	2½	2	4½	14.4	13,800	40,900
20	N_2		7½	Sound	2½	3	4	14.3	14,300	41,200
30	N_2		4½	Sound	2	3	4	14.8	14,100	41,600
0	Cl_2	0	6½	Sound	2	3	4	15.9	13,800	41,900
2	Cl_2	0.40	10	Sound	2½	3	4	15.5	14,000	41,600
5	Cl_2	1.00	7¼	Sound	2	3	4	15.6	14,400	42,200
10	Cl_2	2.00	10	Sound	2	2	3½	15.8	13,800	41,300
20	Cl_2	4.00	10	Sound	2	2	4	14.3	13,600	40,500
30	Cl_2	6.00	10	Sound	2	2	3½	15.1	14,000	41,400

*Treated with 0.02 lb. Cl_2/lb. metal at 1400° F., superheated 15 min. at 1700° F., gassed at 1500° F., then treated with Cl_2 at 1400° F. 300-lb. melt.

Chlorination in Premelting Pots: The previous section showed considerable benefit to be gained by chlorination in the pouring crucibles. Since magnesium alloys usually are melted in large premelting pots[6], it would be more economical if the chlorination could be carried out at this stage of the melting operation. Therefore, the effect of subsequent transfer of the metal to pouring crucibles was investigated (Table 14).

There was little significant change in the porosity rating of the panels when non-chlorinated metal was transferred from the premelting pots to the pouring crucibles. If anything, the soundness of the metal in the crucible was better than in the premelting pots, but the rating was still quite low. The slightly higher rating after transfer may be partially due to the better pouring conditions from the crucible than from the ladle used to dip from the premelting pot. When the metal was chlorinated in the premelting pots there was a definite improvement over non-chlorinated metal. Some of this benefit was lost in subsequent handling of the metal, but the soundness rating was better than when the metal was not chlorinated.

Fluxing Methods Investigated

To determine the reason for the increase in porosity after transferring chlorinated metal, the effect of fluxing methods was investigated. Two extreme cases were used: in one a scoop of flux was placed in the bottom of the crucible before filling, and in the other no flux was used except a very small amount sprinkled on the metal to keep down burning while filling the crucible.

When the metal was not chlorinated, there seemed to be a slightly better soundness rating when no flux was mixed in with the metal while filling the crucible.

When the metal was chlorinated in the premelting pots, and the flux was mixed in while filling the crucible, the results were very much the same as with the commercial practice. However, when flux was not mixed in while filling the crucible, the porosity rating approached more closely the value obtained when panels were poured directly from chlorinated metal in the premelting pot. Despite the use of the best fluxing practice, there always was more porosity after chlorinated metal was transferred from the premelting pots to the pouring crucibles.

Influence of Flux on Gas Porosity: Since the flux seemed to have an adverse influence on the gas porosity in transferring the metal from the premelting pots to the pouring crucibles, the effect of possible moisture in the flux was investigated.

The flux as supplied by the manufacturer is substantially free of moisture. However, some of the ingredients are hygroscopic and, therefore, protection of the flux during use is important. To illustrate this a drum of flux was left uncovered in the foundry for a period of time. Regular batches of ingot "H" alloy were melted in crucibles at intervals and triangular panels were poured. After only 3 days exposure the soundness rating decreased from 8½ to 6½ in.

When 4 lb. of flux, which was deliberately mixed with 3 per cent of water, was added to 100 lb. of "H" alloy, the soundness decreased from a rating of 7 in. to 4 in. free space. Therefore, drums of flux in the melting areas should be carefully covered except during immediate use in order to prevent moisture pick-up.

Discussion

The presence of gas in magnesium alloys can lead to a condition indistinguishable in the radiograph from microshrinkage. Photomicrographs of gas porosity and microshrinkage are shown in Fig. 12. The appearance of each is the same. The fact that microshrinkage can exist in the absence of any gas is indicated by the presence of considerable porosity in the rectangular panel even after full chlorination has completely removed all porosity in the triangle panel.

Table 12

EFFECT OF METAL SOURCE ON POROSITY, "H" ALLOY

Source	Porous** No.	Porous** Per Cent	Sound** No.	Sound** Per Cent
Riser Scrap, not dried	34	100	0	0
Riser Scrap, dried 1 hr.	44	60	29	40
Scrap, dried 2 hr.	11	55	9	45
Ingot, not dried	0	0	13	100
Ingot, dried 1 hr.	2	5	38	95
Premelt*	15	20	59	80

*Scrap, melted in a 1500 lb. premelting pot, then transferred to a crucible, superheated, and poured.

**If a mold of test bars contained at least one test bar which was porous by radiographic inspection, the mold was listed as porous.

Table 13

EFFECT OF Cl_2 ON QUALITY OF COMMERCIAL CASTINGS

Cstg. No.	Run No.	Alloy	Cl_2, lb. per lb. metal	Wt. of Melt, lb.	Method of Melting	Radiographic Estimation* of Tensile Strength, psi.
1	1	C	0	300	Open Pot	19,800
			0.0064	300	Open Pot	29,500
1	2	C	0	300	Open Pot	21,200
			0.011	300	Open Pot	25,900
1	2	C	0	300	Open Pot	22,900
			0.031	300	Open Pot	27,300
1	4	C	0	300	Open Pot	20,900
			0.023	300	Open Pot	34,000
1	5	C	0	300	Open Pot	19,700
			0.02	300	Open Pot	30,200
2	6	C	0	350	Crucible	29,700
			0.02	350	Crucible	30,400
3	7	H	0	500	Crucible	23,200
	8	H	0.02	500	Crucible	31,500
4	9	H	0	500	Crucible	27,600
	10	H	0.02	500	Crucible	30,300
5	11	H	0	500	Crucible	23,200
	12	H	0.02	500	Crucible	32,900
6	13	H	0	500	Crucible	27,100
	14	H	0.02	500	Crucible	27,500

*Estimated at the most porous place in each casting. Since the porous areas examined may be much smaller in area than the casting section in which they are found, these estimated strengths are lower than the true strength of the whole section. These particular castings were chosen because they represented unusual porosity problems.

Table 14

EFFECT OF Cl_2 IN PREMELTING POTS FOLLOWED BY TRANSFER TO POURING CRUCIBLES, "H" ALLOY

Panel Poured from	Conditions of Pouring	Cl_2	Soundness Inches Triangle Panel	No. of Panels
**Premelting Pot	Commercial	No	3.1	80
Crucible	Commercial	No	4.0	115
Premelting Pot	Commercial	Yes	7.8	103
Crucible	Commercial	Yes	5.7	102
Crucible	*Flux Stirred in by Pouring	No	3.5	5
	Flux not Stirred in	No	4.7	10
Crucible	Flux Stirred in	Yes	5.5	6
	Flux not Stirred in	Yes	6.6	20

*Flux was placed in bottom of crucible before pouring metal from the premelting pot so that the stream of metal churned the flux into the forming pool of metal.
**Tilting type pots holding about 1500 lb. of metal. Alloy is melted and held in these pots, transferred to pouring crucibles as needed.

It has been demonstrated that of all the gases commonly encountered in the foundry only hydrogen and nitrogen will cause gas porosity. Of these hydrogen is by far the more serious. Hydrogen has a temperature and pressure dependent solubility in magnesium. Winterhager[5] determined the solubility for one atmosphere pressure to be roughly 26 mls. of hydrogen in 100 gms. of molten magnesium, but only about 20 mls. in the solid state at the melting point. The data are scattered, but probably represent a minimum solubility of hydrogen.

Hydrogen

If enough hydrogen is present to exceed the solubility at a pressure of one atmosphere plus the metal head at the freezing temperature, the gas will be precipitated as spherical bubbles, as shown in Fig. 6.

As the metal freezes, the contraction will cause interdendritic voids. These normally are filled by liquid metal from the unfrozen parts of the casting and, finally, from the risers. The partial pressure of hydrogen in each newly formed void is zero and, therefore, any hydrogen in the metal will diffuse into it. The pressure of the liquid feed metal acting to fill the void will be opposed by the pressure of any gas present in the void. When the two pressures are equal the flow of liquid metal will cease. With no restrictions in the casting due to design the pressure of the liquid metal normally will be atmospheric plus its own head. Under these conditions, in order to prevent the metal from filling the void, the gas pressure must be at least equal to atmospheric pressure. Therefore, the amount of hydrogen in the metal must exceed the solubility at one atmosphere.

If the efficiency of feeding* is decreased in any way, the amount of gas necessary to prevent filling of the void with metal will decrease with the feeding pressure, since the pressure of hydrogen is directly related to the solubility. If the efficiency of feeding drops to zero, the voids will not be filled even in the complete absence of gas.

This paper was secured as part of the Program for the 1945 "Year-Round Foundry Congress" and is sponsored by the Aluminum and Magnesium Division of A.F.A.

Magnesium is fortunate in having a high solubility for hydrogen at the melting point. This means that, if the casting design is good, the problem of gas in magnesium castings is a minor one. When the solubility is low at the freezing point, as for example in aluminum, any small amount of gas present will exert atmospheric pressure. In this case, gas becomes a major problem even with the best casting design.

Helium

If helium is saturated with water vapor at 165° F. and atmospheric pressure plus metal head pressure assumed to be 84.3 cm. Hg, there will be 0.0251 lb. of water per cu. ft. of helium (Table 6). The volume of helium was measured and the concentration of the water was calculated at 84.3 cm. Hg and 68° F.

*By efficiency of feeding is meant the ratio of the pressure on the liquid at the void to what it would be if the liquid at the void had a continuous and frictionless path to the atmosphere.

If this water vapor were to completely react with the magnesium, 14.5 liters of hydrogen would be liberated for every cu. ft. of helium introduced.

From the data in Table 6 it is found that porosity first appeared when one cu. ft. of helium was introduced. This is equivalent to a maximum of 14.5 liters of hydrogen. At this time there were about 240 lb. of metal in the crucible. If we take Winterhager's figure[5] of 20 mls. of hydrogen per 100 gms. of metal as the solubility at one atmosphere, it would require 22 liters of hydrogen to saturate the 240 lb. of metal. Even assuming complete reaction with the water vapor, less than atmospheric pressure of hydrogen was needed to produce porosity in the panel. After 15 cu. ft. of helium or an equivalent of 216 liters of hydrogen had been introduced, there still was no bubble formation. This is evidence that the total reaction—decomposition of water vapor and subsequent solution of hydrogen—is only about 10 per cent complete. Thus a pressure corresponding to only 1 to 2 liters of hydrogen in 240 lb. of metal is sufficient to produce porosity in the triangular panel, indicating a very low feeding efficiency for this type of casting. On the other hand, the test bars did not become porous until 15 cu. ft. of helium had passed through the metal. On the basis of 10 per cent reaction efficiency, this is equivalent to 22 liters of hydrogen. Since this is close to the atmospheric solubility of hydrogen, it indicates that the feeding efficiency of the test bar mold is high.

Porosity Visible

In Table 4, porosity first became visible after bubbling dry molecular hydrogen for 5 min. If the rate of flow of hydrogen is assumed to be the same as for dry helium (Table 6), this flow is equivalent to about 70 liters. Since in the foregoing discussion it was shown that at most 14.5 liters of hydrogen from water vapor was sufficient to cause porosity in the triangular panel, the gassing of metal by water vapor is much more effective than by molecular hydrogen.

That the solubility of hydrogen in molten magnesium alloys is dependent on presure is shown by the fact

In view of the foregoing, the possible sources of hydrogen in the

that hydrogen can be removed by standing, bubbling helium or bubbling chlorine. In each of these cases the partial pressure of hydrogen is initially zero, both above the melt and in the bubbles of helium or chlorine. For this reason the hydrogen will diffuse out of the metal into the area of lower pressure.

It is interesting to note (Figs. 5 to 10 and Tables 3, 4, and 5) that it requires more than 2 hr. to remove hydrogen by standing, more than 30 min. with helium and only 20 min. with chlorine. This may be explained by the fact that both the helium and chlorine bubbles increase the surface through which the hydrogen can diffuse, and the chlorine may react with the hydrogen to maintain the partial pressure at zero.

Because a large proportion of the metal melted in the foundry is remelted scrap, any continuous source of hydrogen will soon cause the hydrogen content of the metal to build up to its saturation value.

In view of the foregoing, the possible sources of hydrogen in the foundry should be critically analyzed. These sources can be divided into four main groups: (1) Atmosphere; (2) metal charge; (3) flux; (4) tools.

Atmosphere

There is moisture in the air at all times, and in the hot, humid days of summer the problem may become serious. The moisture in the air may act directly on the surface of the molten metal or indirectly on the flux, scrap or ingot charge, and tools which come in contact with the melt. Combustion products contain an appreciable amount of water vapor and may contribute to the hydrogen pick-up of the metal. Under ordinary conditions the partial pressure of hydrogen over the melt does not become sufficient to allow solubility and, therefore, direct gassing through the surface of the molten metal by the moisture of the air is not appreciable.

Metal Charge

The scrap metal returned for remelting may be an important source of moisture. This may be due to several causes. If a water blast is used to knock out cores or if the scrap is allowed to stand outdoors, it may be actually wet. Corrosion products consisting of MgO and $Mg(OH)_2$ may accumulate on the surface of the metal even though it is not actually wet. Water vapor is liberated when $Mg(OH)_2$ is heated to the temperature of molten magnesium. Any contamination of a melt by oil also should be avoided.

If metal is reclaimed from sludge, it may contain sufficient flux to pick up moisture on humid days. Even the ingot metal may carry hydrogen into the molten metal if it becomes exposed in the ways mentioned for scrap metal.

The effects of moisture and atmosphere on the metal charge can be partially corrected by drying the metal for at least ½ hr. at a temperature above 212° F., if the metal is not too badly oxidized. Sand blasting is an effective way to remove corrosion products.

Flux

The fluxes used for the protection of magnesium alloys, while essentially anhydrous at the start, are all hygroscopic and will pick up moisture from the air if left exposed. The effect of moisture in the flux can be aggravated by improper use and handling.

The best precautions are to keep the flux drums tightly covered and to avoid an excess of flux where its use its of doubtful value, such as in

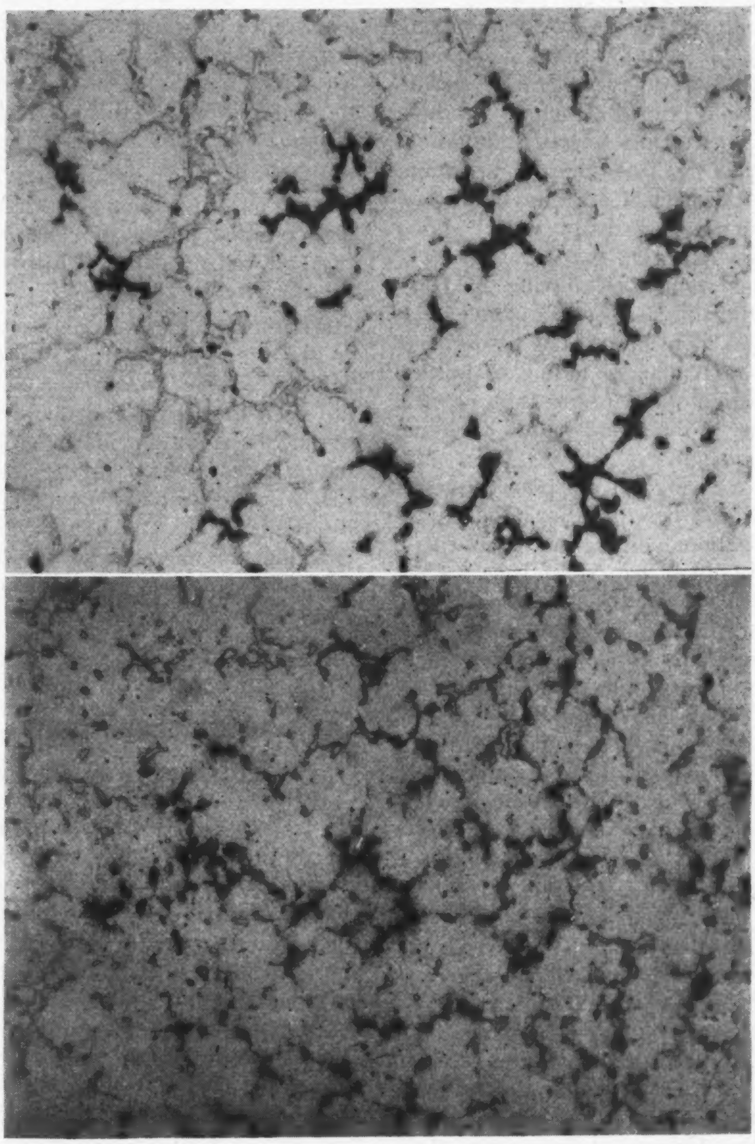


Fig. 12 — Top — Photomicrograph showing voids due to the presence of gas in as-cast magnesium alloy. 100x. Bottom — Photomicrograph showing microshrinkage in as-cast magnesium alloy. 100x.

the bottom of a crucible before pouring in the molten metal. Techniques recommended in the literature[6] will be satisfactory.

Tools

Stirrers, skimmers and ladles invariably become covered with flux which will pick up moisture from the air if left standing for any length of time. Such equipment should be thoroughly heated, to a red heat if possible, to eliminate moisture before placing in the metal.

It has been shown that there is a problem connected with the solubility of hydrogen in magnesium alloys, although it is not as serious as with some other metals. Because of the high solubility of hydrogen in solid magnesium at atmospheric pressure, the effects of gas porosity can be overcome by efficient feeding. Therefore, the problem of gas is secondary to the problem of casting design and proper gating and risering practice. With perfect feeding efficiency and normal foundry melting and superheating technique, the problem of gas porosity in magnesium alloys is substantially eliminated. However, in practice perfect feeding can not always be realized due to the engineering requirements of the castings produced. Therefore, gas porosity becomes increasingly important as the casting design becomes more difficult.

Problem Made Complex

The problem is made more complex due to the fact that all variations of feeding efficiency may exist in a given casting. Thus even complete removal of gas may leave certain areas still porous. Since feeding is not perfect in all sections of the ordinary casting, variations of gas content of the metal may cause variations in porosity during the production of a given casting.

The tendency of hydrogen to increase the porosity can be minimized by general foundry precautions leading to the exclusion of moisture from the molten metal. It is sometimes difficult to exclude all sources of moisture, and a general accumulation of hydrogen to the saturation point may result.

Since the solubility of hydrogen is pressure as well as temperature dependent, the removal of hydrogen from the molten metal can be effected by standing, bubbling with helium, or bubbling with chlorine. Of these, the most efficient is chlorine.

References

1. Erickson, James, *"Degassing Aluminum,"* LIGHT METAL AGE, vol. 2, no. 4, p. 19 (1944).
2. Draper, C. R., *"Volatile Chlorides for Degasification and Grain Refining,"* LIGHT METALS, no. 4, p. 98 (1941).
3. Rhines, F. N., *"The Influence of Gas-Metal Diffusion in Fabricating Processes,"* METALS TECHNOLOGY, T.P. 1645 (Jan., 1944).
4. George, P. F., *"A Numerical Method for the Routine Metallographic Examination of Commercial Magnesium Alloys,"* A.S.T.M. Preprint 33 (1944).
5. Winterhager, H., *"Über die Löslichkeit von Wasserstaff in Al und Mg,"* Aluminum-Arch., no. 12 (1938).
6. Nelson, C. E., *"Melting and Refining of Magnesium,"* METALS TECHNOLOGY, August, 1944.
7. Busk, R. S., *"A Correlation of the Mechanical Properties and Radiographic Appearance of Magnesium Alloy Castings."* Symposium in Radiography, A.S.T.M. (1942).

Purpose of Committee on INSPECTION OF CASTINGS

By Harold W. Warner, Chairman, Inspection of Castings Committee

THE A.F.A. Committee on Inspection of Castings was formed last year for the specific purpose of raising the quality of inspection for the consumers. In forming the committee, the A.F.A. made an effort to obtain from companies familiar with the problems of inspection from both the foundry production and castings buyers' standpoint, as it is realized that competition from the field of other methods and products will increase and be more intense following the war.

The committee, having held its first meeting at the time of the 1944 Buffalo Convention, has before it a long time plan of aiding in raising inspection standards to improve the quality of the foundry product going to the engineering field.

In carrying out this plan the committee has been meeting monthly at the National office, for the purpose of obtaining papers and preparing material of interest to the membership of the American Foundrymen's Association. The committee feels that the inspection of castings is of vital interest to all producers as well as to all users of castings. The war has brought about the increased use of many tests in the inspection of castings and the trend seems to be that many of these rigid requirements will be maintained after the war. This means that all companies that want to maintain their position will have to ship castings that are satisfactory to the customer.

Forward looking companies, of their own accord, have gone to the use of X-Ray, Gamma Ray and other non-destructive testing either for the purpose of improving their castings or for inspection purposes. The committee members are not so much concerned about this side of inspection as they are about the type of inspection, or lack of inspection, which permits the shipping of castings that are not up to a high standard, and which if sent out would give the industry a black eye. Every poor casting shipped out from a foundry has the effect of lowering the reputation of the casting industry.

With all this in mind, the Committee on Inspection of Castings has obtained papers of general nature as well as papers which show the new trends.

The committee is going forward on the preparation of an Inspectors Manual. The preliminary outline has been drawn up and definite assignments have been made. All the material to be used in the Inspectors Manual will first be published in the "American Foundryman," enabling the membership to make suggestions as to what the completed manual should contain.

Give Recommendations To Buyers of Castings

THE A.F.A. Cost Committee is urging Association members to make use of the recently revised Recommendations to Buyers of Castings. First issued in 1931 and revised in 1943, this booklet contains information that buyers should give in requesting quotations. Members are urged to obtain copies of the 8-page pamphlet and furnish them to their customers, as they will aid greatly in facilitating estimates of castings cost.

Effect of Composition on Mechanical Properties of Sand Cast COPPER-TIN-LEAD-ZINC ALLOYS

• *Mechanical property determinations on a series of sand-cast copper-base alloys—calculated effects of composition changes—are presented graphically and in tabular form.*

•

By W. T. Battis,
Central Res. Lab., American Smelting & Refining Co., Barber, N. J.

SINCE practically all of the copper-base alloys in common use for sand castings are included in the quaternary system copper-tin-lead-zinc, it was believed that a survey of the properties of the alloys in this system might be helpful in reducing the number of alloys and would, also, provide some basis for composition limits in setting up specifications.

The literature contains only a few references on cast alloys, and the values reported, especially per cent elongation, are generally so much lower than those found in this investigation that it is believed that the casting techniques differed too much to allow comparison.

The more recent papers on sand casting alloys[1] do not cover changes in composition as much as different methods of casting, and where methods similar to those described here were used, the results compare very well for the few compositions reported.

Experimental Method

Clean muffled rifle shells were melted in a No. 45 clay graphite crucible, using a forced-draft coke-fired pit furnace. Clean, bright copper wire was then added, followed where necessary by electrolytic zinc and electrolytic tin. No charcoal, fluxes nor phosphorus were used. When all ingredients were melted, the crucible was removed from the furnace and the melt stirred thoroughly with a graphite rod and skimmed clean.

Upon the attainment of proper

Table 1

MECHANICAL PROPERTIES OF SAND-CAST COPPER-TIN-LEAD-ZINC ALLOYS

Alloy No.	Composition, per cent Cu	Sn	Pb	Zn	Tensile Strength, psi.x1000	Yield Strength, psi.x1000	Elongation, per cent in 2 in.	Brinell Hardness
1	96.8	0	0	3.2	29.7	8.5	49	50
6	85.7	0	0.01	14.3	30.0	8.0	44	48
					29.6		50	
7	85.4	0	1.0	13.6	29.6	7.3	32	41
					30.5	7.3	33	
8	80.7	0	6.1	13.2	24.1	7.0	18	40
					24.5	6.5	20	
9	75.0	0	13.6	11.4	18.2	7.0	18	39
					18.1	7.0	13	
11	70.8	0	Nil	29.2	30.6	7.3	56	57
					31.2		49	
12	70.4	0	1.3	28.3	32.8	7.0	66	55
					32.9	7.2	67	
13	67.5	0	6.2	26.3	30.0	7.0	48	42
					30.5	8.3	52	
14	61.6	0	14.8	23.6	24.2	8.8	23	37
					25.8	9.5	27	
16	61.3	0	0.3	38.4	47.1	13.5	63	65
					44.8	13.5		
17	60.9	0	1.3	37.8	45.4	13.8	41	65
18	59.4	0	4.4	36.2	31.9	14.0	18	57
					38.8	15.5	25	
19	58.9	0	6.4	34.7	30.2	11.7	22	48
					29.8	11.7	21	
121	93.2	4.7	Nil	2.1	39.3	16.0	51	69
					38.7	15.5	51	
122	92.7	4.5	0.9	1.9	33.5		29	
					29.1		31	
123	89.4	4.3	5.2	1.1	35.1	14.5	32	53
					35.2	15.0	26	
124	85.5	3.7	9.9	0.9	33.6	13.0	13	50
					33.3	13.0	12	
26	89.9	4.9	0.2	5.0	39.2	15.8	51	57
					39.4	16.3	53	
27	89.4	4.8	1.2	4.6	37.2	16.0	39	57
					35.0	16.3	30	
28	86.0	4.6	6.1	3.3	36.8	16.3	32	74
					38.2	16.3	41	
29	81.4	3.7	13.1	1.8	31.4	13.3	27	53
					31.9	13.3	28	
31	80.7	4.8	0.1	14.4	39.7	15.0	38	58
					43.4	15.3	48	
32	80.3	4.5	1.3	13.9	43.5	15.0	49	60
					41.8		48	
33	76.6	4.3	6.5	12.6	37.0	13.5	42	76
					38.7	13.0	48	
34	71.0	3.8	14.9	9.9	31.7	13.5	28	66
					30.4	13.0	28	
36	66.1	4.6	0.03	29.3	38.6	24.0	1	93
					33.4		1	
37	65.9	4.4	1.1	28.6	33.1	23.5	2	93
					30.2	23.5	1	
38	63.6	4.3	6.3	25.8	29.8	21.0	3	77
					27.5		1	
41	89.0	9.5	0.2	1.3	46.0	19.0	42	69
					44.0	19.0	42	
42	88.4	9.4	1.3	0.9	42.2	19.0	36	69
					44.1	19.5	42	
43	85.0	8.5	6.2	0.3	42.0	19.5	39	61
44	78.8	7.1	13.5	0.6	35.0	17.5	30	53
					35.2	17.5	30	
45	71.8	3.5	24.6	0.1	24.5	15.0	18	49
46	85.2	10.0	Nil	4.8	47.8	20.0	30	69
					47.6	20.0	22	
47	84.7	9.8	0.9	4.6	41.8	18.8	25	69
					41.3	18.8	25	
48	80.6	9.4	6.1	3.9	43.5	17.8	34	65
					43.2	18.3	34	
49	74.7	8.3	13.5	3.5	39.2	17.0	31	61
51	76.2	8.5	0.1	15.2	27.7	24.0	2	86
					28.3	24.0	2	
52	75.4	8.4	1.2	15.0	25.0	21.5	2	74
					24.5	21.0	2	
53	72.3	7.9	6.9	12.9	26.0	20.0	2	69
					26.0	21.0	2	
54	65.2	7.2	16.7	10.9	25.0	18.5	4	65
					25.5	18.5	4	
56	61.9	7.8	0.02	30.3	40.5		0	158
57	61.6	7.8	1.3	29.3	39.5		0	158
58	59.3	7.4	5.6	27.7	39.0		0	158
151	68.2	10.6	0.07	21.2	34.3		0	143
					34.0		0	
152	67.7	10.3	1.1	20.9	33.0		0	143
153	65.4	10.2	5.3	19.1	32.4		0	130
					35.0		0	

pouring temperature, two molds were poured (lead-free). One per cent of chemical lead was then added to the balance of the metal in the crucible, the melt reheated to proper pouring temperature, and two more molds cast. The lead content of the remainder of the metal was then raised to 5 per cent and the metal reheated and cast. This was repeated for 10 per cent lead and 20 per cent lead contents.

The pouring temperature was measured with a chromel alumel closed-end thermocouple and a portable potentiometer, and was predetermined by adding 150° F. (± 20° F.) to the liquidus temperature of each alloy as taken from the literature.[2, 3]

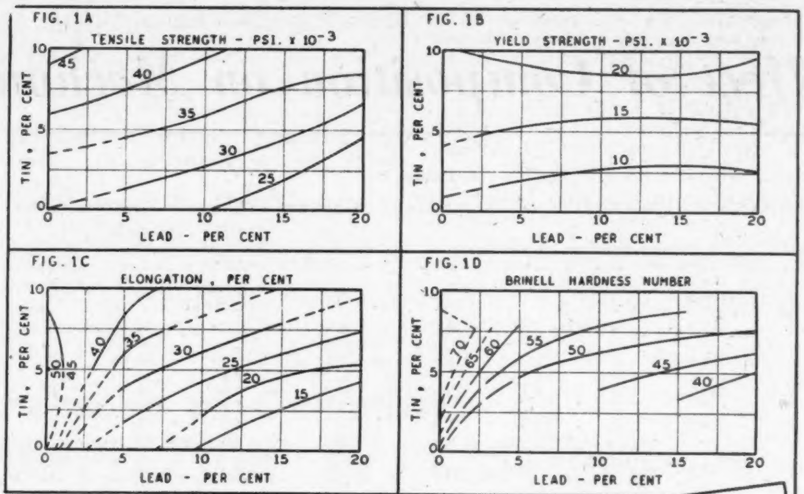
The test bar casting was of the standard Webbert type with a 5/16 in. fin feeding the whole length of the test bar. It was cast vertically (test bar directly below the riser) through a one-inch diameter sprue on top of the riser, the metal dropping from the ladle directly into the bottom of a mold of baked core sand. The castings were shaken out of the mold in from 30 to 45 min. and allowed to air cool to room temperature.

It was found to be impossible to produce sound zinc-free test bars without resorting to radical changes in the melting or casting procedure, so it was decided to accept the lesser evil of making a small zinc addition and extrapolating the curve to zero per cent zinc.

The castings were wire-brushed to remove sand, and the test bar portion was cut off. Samples for chemical analysis were obtained by drilling halfway through the riser just above the web connecting it to the test bar. Each alloy (two castings) was analyzed for copper, tin and lead, and the zinc content was taken by difference (Table 1).

Standard 0.505-in. diameter threaded bars were machined from the casting and tested. Stress-strain curves were made on all bars, using an extensometer reading to 0.0001 in. The yield strengths reported are the unit loads at 0.5 per cent elongation under load.

After fracture, the threaded ends of the test bars were polished for



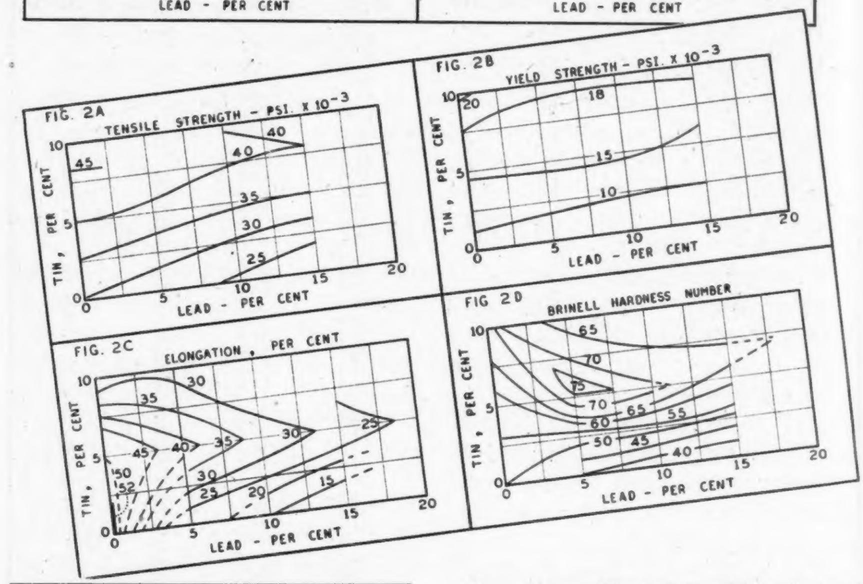


Fig. 1—Top—Effect of tin and lead at zero per cent zinc content on mechanical properties of copper-base alloys.

Fig. 2—Bottom—Effect of tin and lead at 5 per cent zinc content on mechanical properties of copper-base alloys.

This paper was secured as part of the Program for the 1945 "Year-Round Foundry Congress" and is sponsored by the Brass and Bronze Division of A.F.A.

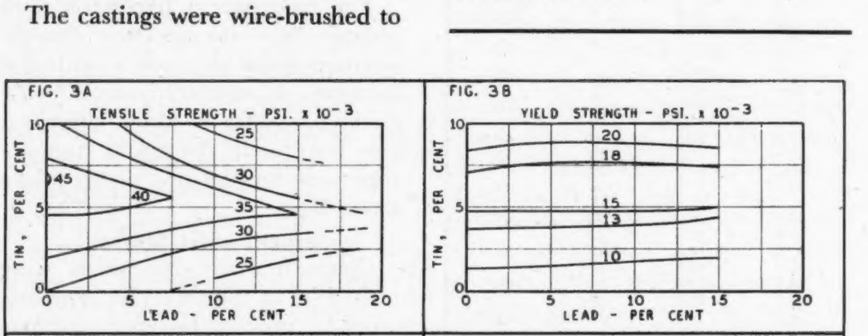
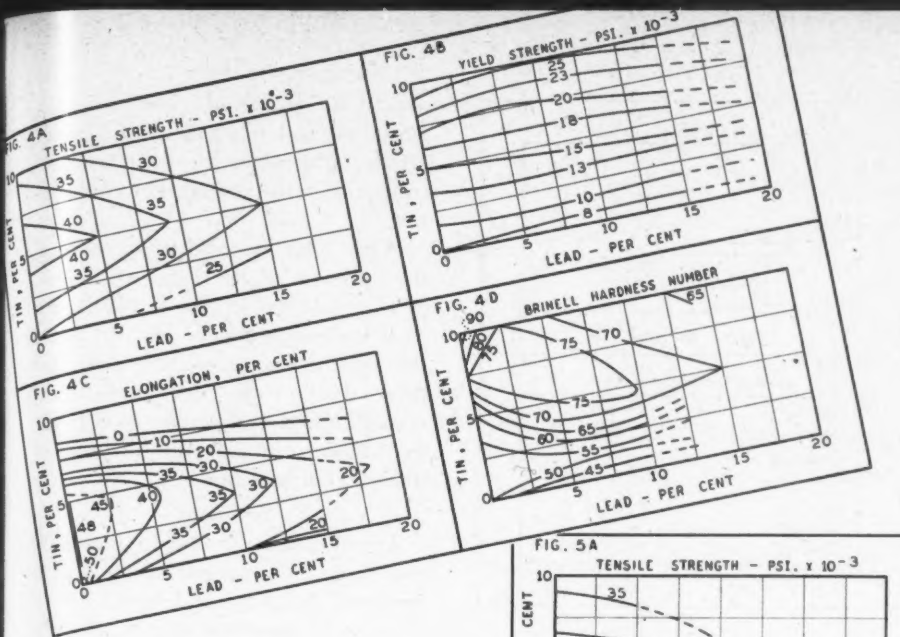


Fig. 3—Effect of tin and lead at 10 per cent zinc content on mechanical properties of copper-base alloys.



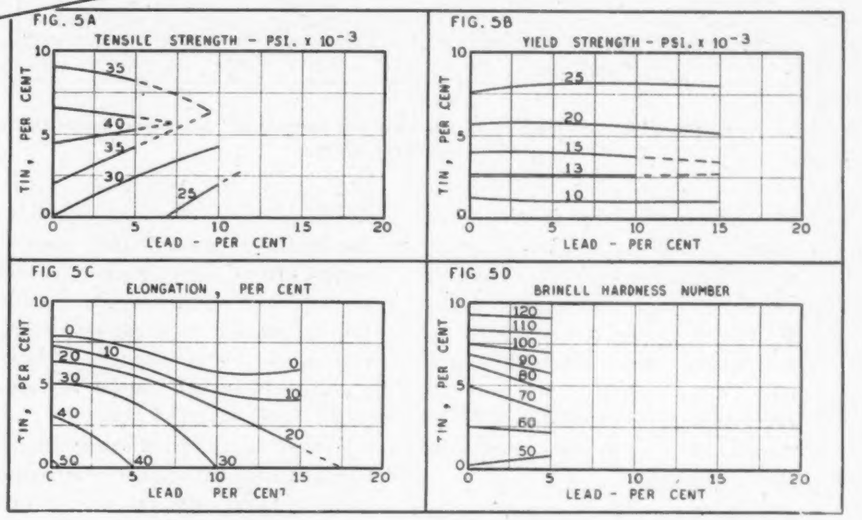


Fig. 4—Above—Effect of tin and lead at 15 per cent zinc content on mechanical properties of copper-base alloys.

Fig. 5—Right—Effect of tin and lead at 20 per cent zinc content on mechanical properties of copper-base alloys.

Brinell hardness determinations and microscopic examination. Brinell impressions were made with a 10-mm. ball, using a 500-kg. load for 30 sec. For microscopic examination, the specimens were etched with potassium dichromate and/or ammonium hydroxide and hydrogen peroxide.

Presentation of Data

The plan of research consisted ideally in making 12 lead-free alloy bases, each containing exactly the nominal amounts of tin and zinc. Thus a curve could be drawn showing the influence of zinc on the properties of alloys containing 0, 5.0 and 10.0 per cent of tin with points at 0, 5.0, 15.0 and 30.0 per cent of zinc. Similar curves also could be obtained from the same points showing the effect of tin on the properties of alloys containing, say, 15.0 per cent of zinc with points at 0, 5.0 and 10.0 per cent of tin. Intermediate values then could be read from the curves.

Since this degree of accuracy in compounding alloys is almost impossible to attain without pre-alloying, especially with high zinc contents, only routine precautions in weighing and melting were observed and, after analysis, the properties of an alloy containing only 29.2 per cent of zinc were modified by calculation to the properties of the nominal composition (30 per cent).

It also will be noted that, ideally, additions of lead would not change the copper-tin-zinc ratio but only the percentage of each. Again it is impossible to attain this ideal and, as lead was added and the metal reheated, the ratio of copper-tin-zinc did change.

There are, therefore, two major deviations from the ideal which must be taken into account:

A. Deviation from nominal zinc composition (lead-free).

B. Deviation from nominal tin composition (lead-free).

C. Change of copper-tin-zinc ratio during lead additions.

Methods Used

The method used may be broken down into steps as follows:

Step 1: Calculate the "lead-free analysis" of each alloy, or make the copper, tin and zinc contents equal 100 per cent.

Step 2: Plot the properties of each base alloy versus actual lead content, assuming that Deviation *C* does not exist, i.e., the copper-tin-zinc ratio is assumed to be constant.

Step 3: Plot properties versus actual percentage of zinc at 0, 5 and 10 per cent nominal tin with separate curves for 0, 5, 10, 15 and 20 per cent of lead (a total of 15 curves for each property), the values being read from the curves of properties versus lead content *(Step 2)*. This step assumes that Deviations *B* and *C* do not exist.

Step 4: Plot the properties versus actual percentage of tin at 0, 5, 15 and 30 per cent nominal zinc with separate curves for 0, 5, 10, 15 and 20 per cent of lead (a total of 20 curves for each property), the values being read from the curves representing properties versus lead content *(Step 2)*. This step assumes that Deviations *A* and *C* do not exist.

The purpose of making these admittedly erroneous graphs *(Steps 3* and *4)* is to observe, in a semi-quantitative way, whether for each alloy the trend or slope of the several curves is such that chemical deviations from the nominal composition are introducing significant errors.

Step 5: Corrections for Deviations *A, B* and *C* are made for each sample as follows:

(a) Deviation *A*: Determine from the curves of *Step 3* the increment of each property between the actual zinc content and the nominal zinc content.

(b) Deviation *B*: Determine a similar increment of each property between the actual and nominal tin content from the curves of *Step 4*.

(c) Determine the net effect

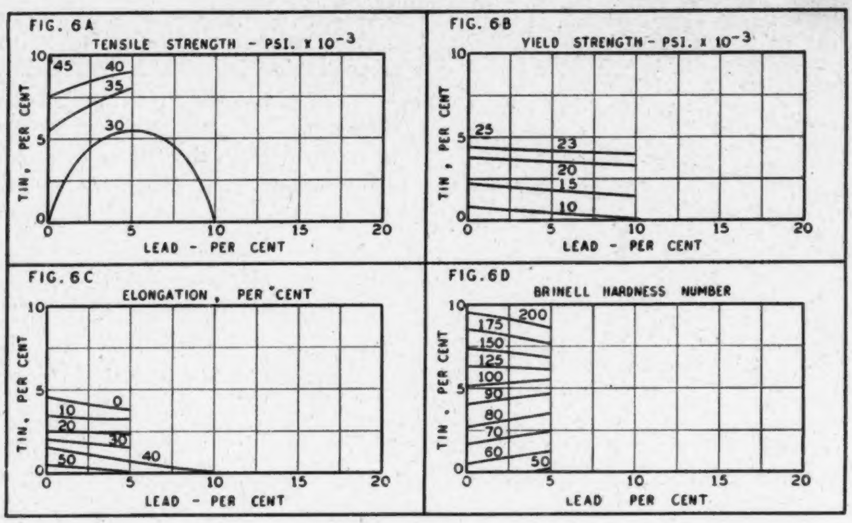


Fig. 6—Effect of tin and lead at 30 per cent zinc content on mechanical properties of copper-base alloys.

of each pair of increments and correct each experimental property datum accordingly. This obviously corrects Deviations *A* and *B* and, since the net result of the correction is to establish the nominal copper-tin-zinc relationship, Deviation *C* is automatically reduced to zero in each case and thus eliminated.

Step 6: The "uncorrected" curves described in *Steps 2, 3* and *4* were again plotted, using the values obtained in *Step 5.*

In all of these calculations, the "lead-free analysis" or copper-tin-zinc ratio was used.

From the curves described in *Step 6*, corrected to nominal composition, Figs. 1 to 6, inclusive, were obtained after calculating the lead content back into the composition. Since zinc has less unit effect on properties than does tin or lead, these sections were made at constant zinc values. For zinc contents between these even values, interpolation must be resorted to.

Discussion

It is acknowledged that the properties of a very wide range of compositions have been reported using only a relatively small number (47) of alloys. However, it is believed that the graphs represent values which are correct within the variations to be expected with duplicate specimens (about ± 5 per cent maximum).

The actual values obtained (Table 1) have been checked against the applicable curves, and they all agree within these limits. Although the effect of impurities is not known, the properties obtained on commercial alloys by the same method of casting are in substantial agreement with those reported here.

While a detailed discussion of each graph will not be attempted, some general remarks are in order.

Changes in direction of the lines are due chiefly to the appearance of new phases, although some changes indicate a difference in the degree of coring present.

Line Direction

From the lack of uniformity of direction of the lines, it is evident that the use of a "coefficient of equivalence" to simplify an understanding of the system is inadvisable except within very narrow limits. It is also evident that if such a coefficient be used within satisfactorily narrow limits for one property, it may not apply to another property.

The number of alloys studied does not permit drawing the boundaries of the phase fields. In general, the tin-free alloys consist of all alpha, except for the one containing 40 per cent of zinc, which also contains beta. All of the alloys made containing tin consist of alpha plus partially decomposed beta (alpha plus delta), the amount depending on composition.

In the low-tin and low-zinc alloys, this beta is present because of coring, and the all-alpha equilibrium state can be established by annealing. As the amount of beta (alpha plus delta eutectoid) increases, the alloys become harder and more brittle; and when the beta becomes continuous, the elongation drops to zero.

With high tin and zinc content, the addition of the higher amounts of lead resulted in two liquid layers. This was immediately obvious when the castings were shaken out, and these bars were discarded. Not enough alloys of this type were made to allow drawing the two-liquid phase boundary lines.

Summary

Tensile strength, yield strength, per cent elongation and Brinell hardness have been determined on a series of sand-cast alloys, and the effect on these properties of changes in composition has been calculated and presented graphically for the quaternary system copper-tin-lead-zinc, within the limits of commercial use.

Bibliography

1. Curran, J. J., Bolton, J. W., Wolf, F. L., and Martin, W. E., *"Studies of Machined versus As Cast Specimens for Copper-Base Alloy Sand Castings,"* PROCEEDINGS, A.S.T.M., vol. 42, pp. 199-214 (1942).

2. Bauer, O., and Hansen, M., *"Der Einfluss von dritten Metallen auf die Konstitution der Messinglegierungen,"* I—DER EINFLUSS VON BLEI, Z. METALLKUNDE, vol. 21, pp. 145-151 (1929), and II—DER EINFLUSS VON ZINN, Z. METALLKUNDE, vol. 22, pp. 387-391, 405-411 (1930), and vol. 23, pp. 19-22 (1931).

3. Blumenthal, B., *"The Constitution of the Copper-Tin-Lead System,"* METALS AND ALLOYS, August 1932.

Book Review

Metals and Alloys Dictionary, by M. Merlub-Sobel. Red cloth bound, 238 pages. Published by Chemical Publishing Co., Inc., Brooklyn, New York. Price, $4.50.

A concise dictionary of over 10,000 metallurgical terms, compositions, properties, and uses of important commercial alloys. Physical constants and properties of chemical elements, descriptions of machinery and processes used in modern metallurgy, and other pertinent information are also presented.

Users may expect that some terms have been omitted, since the number of terms is determined by the size of the book and by the author's selection. Should the user require a more complete definition of any term, he is urged to consult a more extensive reference.

Steel Castings RADIOGRAPHY

By E. L. LaGrelius, East Chicago, Ind., and C. W. Stephens, Granite City, Ill., Supv. Met., Research Lab., and X-Ray Dept. Foreman, Respectively, American Steel Foundries.

• In this issue, Part I of this paper reviews briefly the underlying principles necessary for the production of good radiographs, proposes a concise radiographic terminology and lists the probable causes for casting defects revealed by radiography.

Fig. 6—Radiograph showing gas holes in casting as a result of imperfectly deoxidized metal.

A DISCUSSION of the advantages and limitations of radiography to the steel casting industry should be prefaced by a consideration of the underlying principles upon which the process is based.

The primary purpose of radiography is to disclose the presence of defects or discontinuities in the interior of a casting. This is accomplished by exposing a casting to a beam of X-rays which have the ability of penetrating through the casting without being completely absorbed. The absorption of an X-ray beam is dependent upon the amount of material it must penetrate — the greater the thickness, the greater the absorption.

Therefore, when X-rays pass through a casting containing a defect or discontinuity there will be a variation in the amount of X-rays absorbed. As we are unable to note this variation in absorption, some medium to record this effect is required. A photographic film has this ability and generally is used for this purpose. The prerequisites for a good film are, therefore, that it will register accurately any variation in intensity of the X-rays passing through a casting, and that the absence or presence of a defect be clearly defined as to size and shape.

The important purpose of this part of the discussion is to try to point out which factors an operator can control in producing a satisfactory radiograph.

Equipment

The first of these factors is the selection of equipment to produce the necessary X-rays. This is dependent upon the size, shape and section thickness of the casting which the operator is required to radiograph. The time which can be allotted to securing radiographs and the number of castings are important factors.

Source of X-Rays, kilovolt	*Maximum Section Thickness, in.*
220 to 250	2
400	3
1,000	5
Radium	—

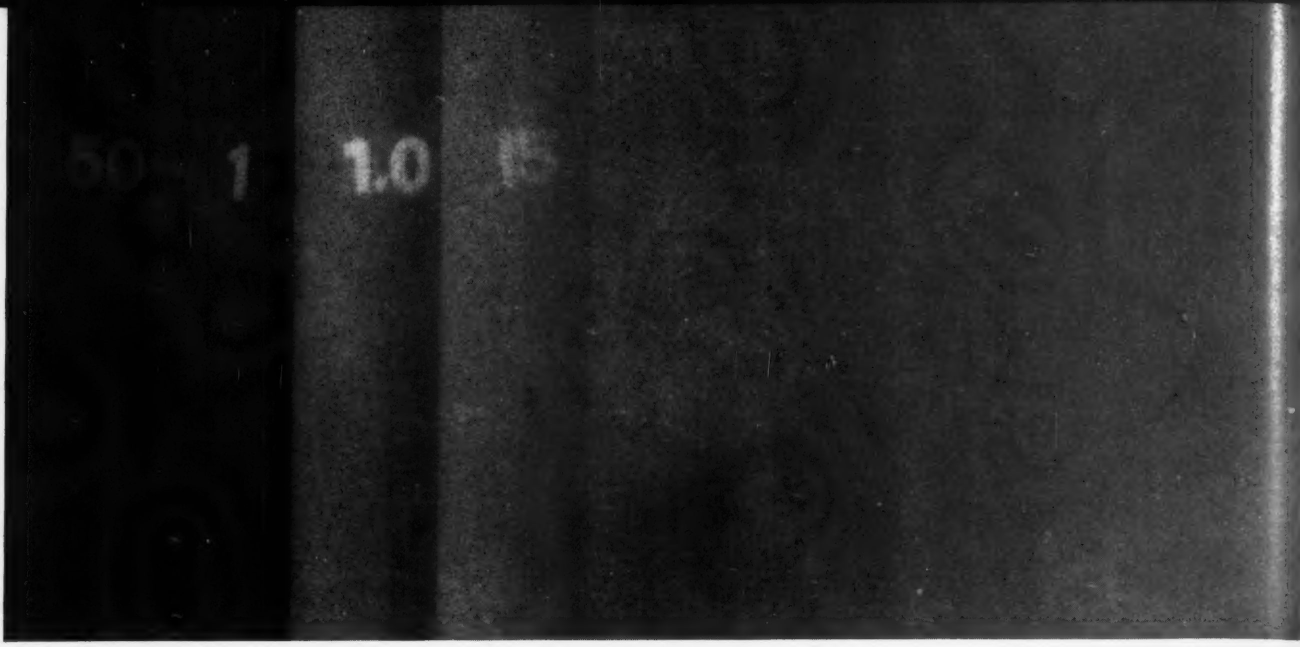


Fig. 2—High contrast film. Step block of 0.5 in., 1 in., 1½ in. and 2 in.

The selection of the unit which will be required also entails the construction of adequate building space, crane service and developing and drying equipment.

In selecting a unit the operator also exercises some control over the contrast of a radiograph. Contrast depends primarily upon the absorption coefficient of the metal, and the absorption coefficient is a function of the X-ray tube voltage. High voltages produce radiographs of low contrast, while low voltages produce radiographs of high contrast. Therefore, using the lowest voltage that will give a readable film in a reasonable length of exposure time is the general rule.

From the foregoing discussion, it would seem that contrast obtainable at a particular voltage should be independent of the thickness of a material, but this is not the rule because of the scattering of X-rays within the material itself. To date, the only practical device to reduce this scattered radiation is the use of 0.010 lead screen on both sides of the film within the cassette. The front screen acts as a filter for the scattered beam and the back screen acts as an intensifying screen.

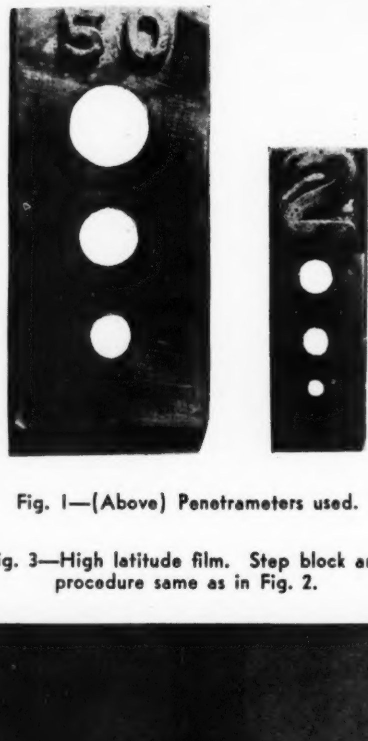
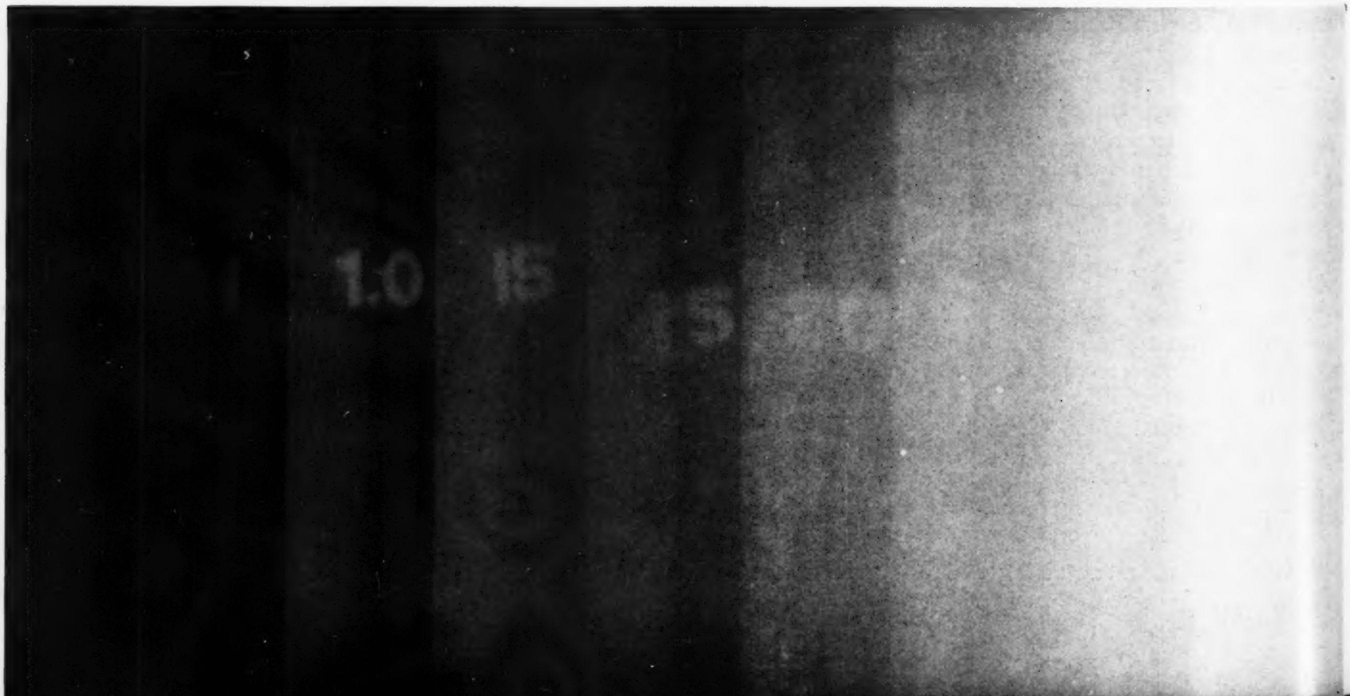


Fig. 1—(Above) Penetrameters used.

Film

The second factor over which an operator has some control is the recording device; that is, the proper selection of film. Radiographers are always endeavoring to increase sensitivity. Sensitivity is defined as the

Fig. 3—High latitude film. Step block and procedure same as in Fig. 2.



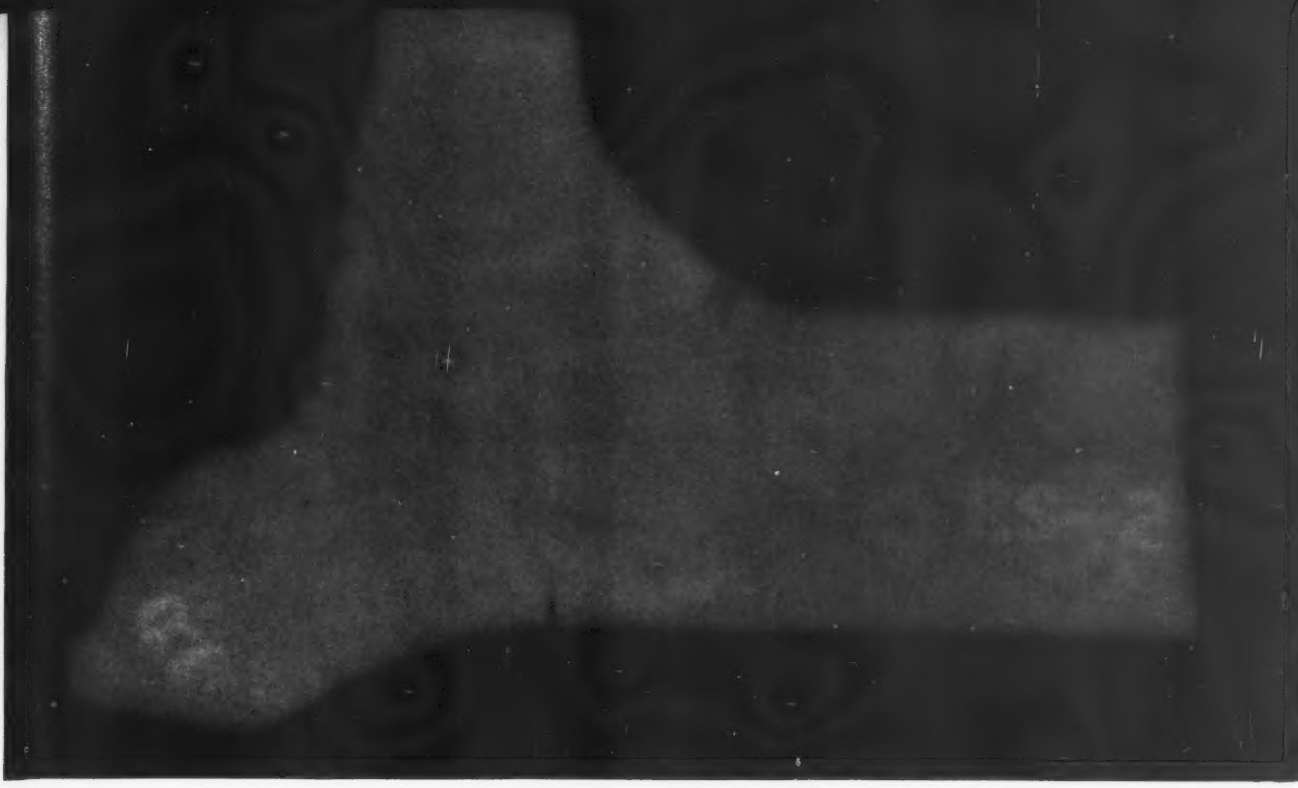


Fig. 4—Radiograph of casting using low density film.

smallest detectable defects in percentage, the size of defect to section thickness. Generally, a sensitivity of 2 per cent can be obtained. A defect of 0.02 in. would be located on a radiograph made of a one-in. section.

In order to determine whether or not a radiograph has the proper radiographic quality, in that all detail structures are visible indicating proper exposure technique, a penetrameter is used.

The penetrameter generally used consists of a thin sheet of the same base metal having the same density as that of the metal to be radiographed. Each penetrameter has an area of ½ by 1½ in. of a thickness equal to 2 per cent of the thickness to be radiographed. In each penetrameter there are three holes having diameters of 2, 3 and 4 times the thickness of the penetrameters, as shown in Fig. 1. A lead numeral indicating section thickness is attached to one side of the penetrameter.

The latitude characteristics of a radiographic film is the exposure range over which various defects are satisfactorily revealed when radiographs are made of castings having widely different thicknesses, as shown in Figs. 2 and 3.

The sharpness or detail of a radio-

Fig. 5—Same as Fig. 4 except higher density film used.

Fig. 7—Radiograph showing gas holes in casting as a result of mold surface moisture.

graph is also dependent upon several factors. The eye detects images of low contrast if the outline is sharply defined. The sharpness of an image may be improved by changing to a smaller focal spot or by increasing tube to film source distance.

Manufacturers today produce three distinctive types of industrial X-ray film:

1. Slow — Fine grain (optimum definition), high contrast (optimum visibility and of low speed).
2. Medium — Large grain, medium contrast, 2½ times speed of slow film.
3. Fast — Large grain, medium contrast, 2 times speed of medium film.

An operator also must decide whether he wishes to use a film of high contrast or high latitude. A film of high contrast possesses a low degree of latitude, and a film having low contrast will possess a wide latitude. It is sometimes necessary when radiographing castings of varying section thicknesses to use a film having a wide latitude, because if a high contrast film were used the thinner sections would appear extremely black and the thicker sections so light that small density changes due to a small defect would be lost in the radiograph.

Radiographic Density

Radiographic density is defined as the degree of blackening of a film, and increases with increasing X-ray intensities. Density also may be defined mathematically as the log-

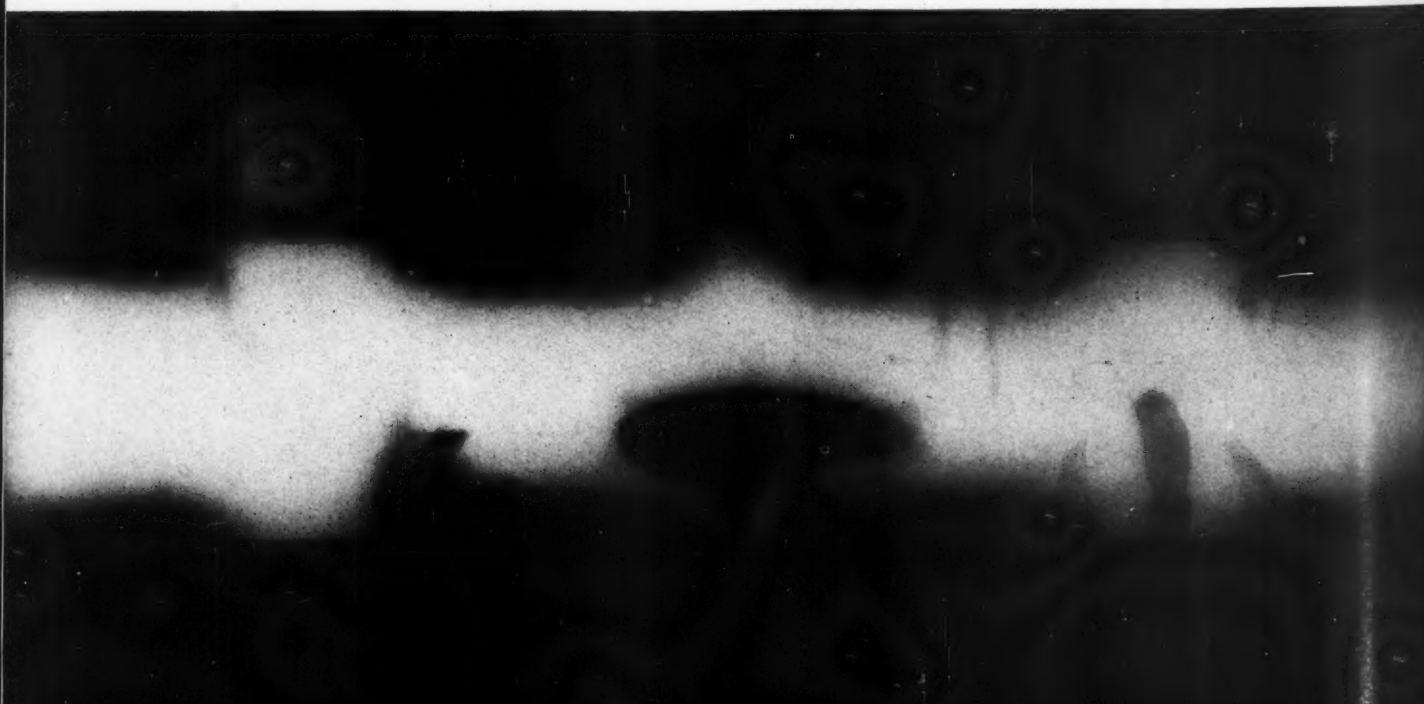


Fig. 8—Radiograph showing gas holes (due to entrapped air) and shrinkage cavities.

arithm of the reciprocal of the transparency of a film $(D = \log \frac{1}{T})$. Thus, a film density of 1.0 means that the blackening is such that only one-tenth of the incident light passes through. For a value of 2.0 only one-hundredth of the incident light passes through. Film densities have become greater, and better viewing equipment has been manufactured. We have experienced many times that harmful defects were not located on radiographs of low densities. Films having densities below 1.5 are unsatisfactory, and densities of 2.0 or over are better. By increasing the density, sensitivity also is increased, as shown in Figs. 4 and 5.

Secondary Radiation

Another influencing factor on the production of good radiographs is proper shielding of film from stray or secondary radiation, created by various objects surrounding film, walls, etc. Secondary or stray radiation does not form any part of the X-ray image and only creates fogging. The influence of these rays may be curtailed by shielding the cassette with sheets of lead on the back and sides.

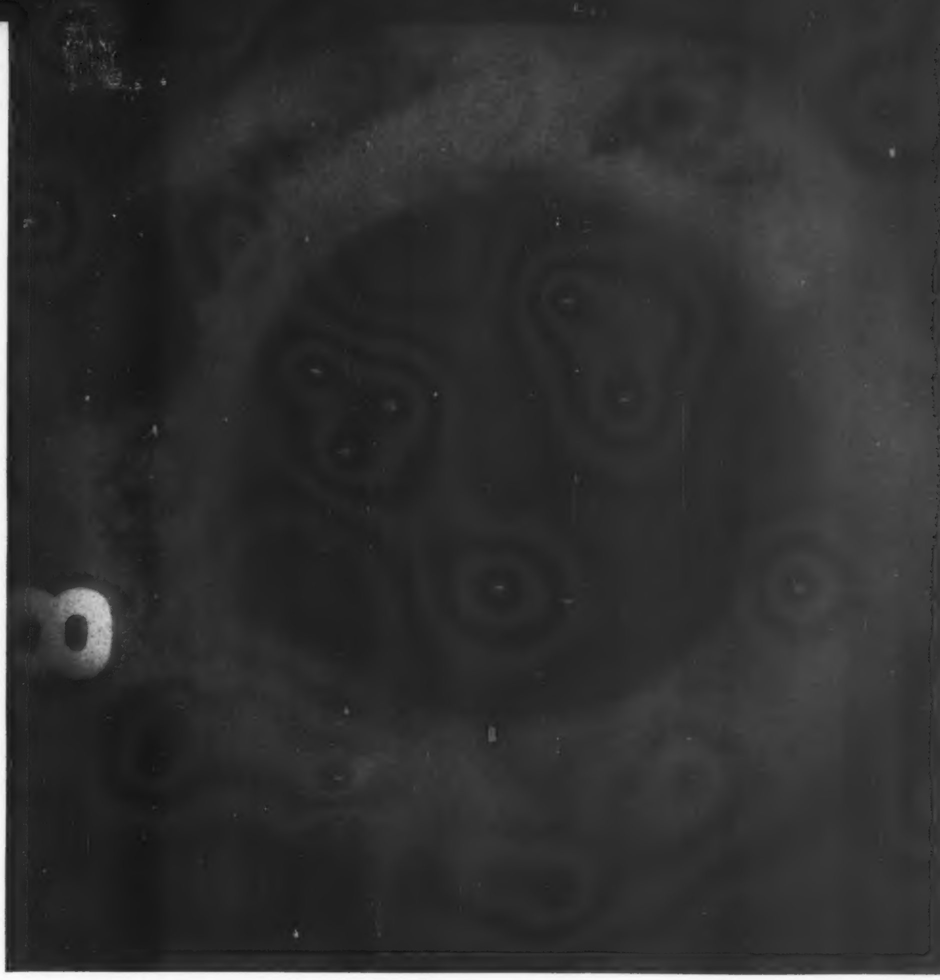
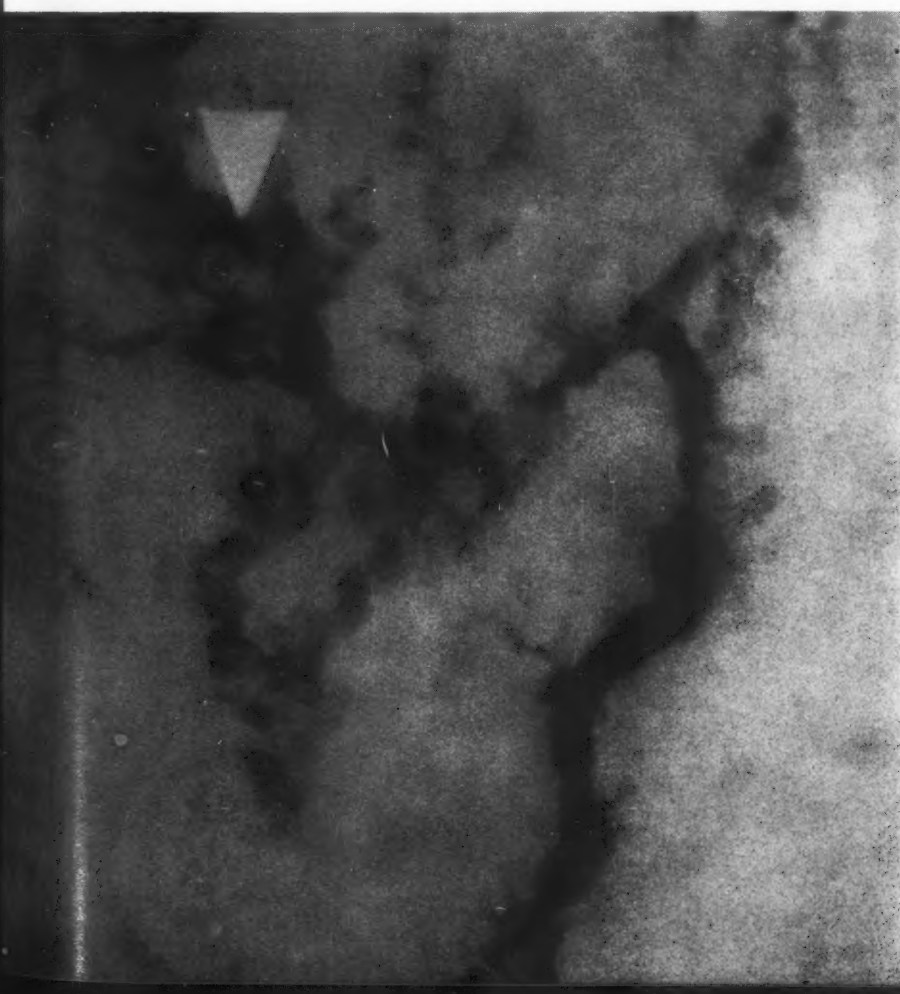


Fig. 9—Above—Radiograph of casting showing shrinkage cavity resembling gas hole.
Fig. 10—Below—Radiograph showing another type of shrinkage.



Now that we have sketched briefly the underlying principles of radiography, let us put these principles to use. The method of diagnosis, as applied to determining the type, size and shape of an image outlined by the variance of film blackening, is the same as the medical profession used in setting up its principles of film interpretation, dissection or sectioning. Once we have compared the image on a radiographic film with a visual inspection of the defect, we are able to state the type of defect in subsequent radiographs having the same image.

Application of Principles

It is well to remember a few vital facts when viewing radiographs: (1) Voids, cavities or other discontinuities in metal of uniform density will appear as dark areas on a film, whereas materials of higher density than the metal will appear lighter on the film. (2) Materials such as sand, ladle lining, etc., will appear as dark areas on the film. (3) Ex-

Figs. 11 and 12 (Above)—Radiographs showing shrinkage in castings.

cess metal on the surface (scabs, fins, etc.) will appear as light areas, whereas surface defects, scratches or depressions will appear dark.

Radiographic Terminology

It is important that a standard terminology be used in interpreting defects on radiographic film. Such a proposed terminology and the probable causes of these defects are given in the following paragraphs.

1. Gas Holes

Gas holes appear as round or elongated, smooth dark spots occurring individually, in clusters or distributed throughout the casting.

This condition is the result of imperfectly deoxidized metal; gas forming during solidification by the evaporation of moisture or volatile material from the mold surface; excessive evolution from a core on account of insufficient baking or venting; or the entrapment of air in the cope surface of a casting due to the inability of the gas or air to escape from the mold cavity before the complete solidification of the molten metal. Radiographs depicting various types of gas holes are shown in Figs. 6, 7 and 8.

2. Shrinkage

Shrinkage appears as a dendritic, filamentary or jagged darkened area.

This condition indicates insufficient feeding of a casting. This defect generally is found in the center wall section or under risers, thick-to-thin sections or improperly fed sections. Radiographs depicting various types of shrinkages are shown in Figs. 9, 10, 11 and 12.

3. Heterogeneities

3.1 Foreign material appears as isolated, irregular, or elongated variations of film blackening, not corresponding to variations in thickness of material nor to cavities. They may be due to the presence of sand, slag or oxides.

This condition is caused by particles of sand from molds or cores, trapped slag or other refractory materials trapped in the metal during the pouring operations. Radiographs of foreign materials are shown in Figs. 13 and 14.

4. Sharp Discontinuities

4.1 Hot cracks appear as ragged dark lines of variable width and numerous branches. They have no definite line of continuity and may exist in groups. They may start at the surface or be internal.

Fig. 13—Radiograph showing sand trapped in metal during pouring operations.

Fig. 14 (Left)—Radiograph showing slag in casting.

Fig. 15 (Below)—Radiograph showing hot cracks in casting.

This condition is the result of the normal contraction of the casting which was restricted by the mold and/or core during or immediately after solidification, the magnitude of the restricting forces being greater than the strength of the metal in the casting at that time. A radiograph of a hot crack is shown in Fig. 15.

4.2 Cold cracks appear as a straight dark line, usually continuous throughout its length, and generally exist singly. These cracks usually start at the surface.

Cracks of this nature may be produced in castings being cooled from an elevated temperature during flame burning, grinding or quenching operations. Any of these operations may produce stresses that exceed the strength of the metal in the casting at some time during or after the operation. Examples of cold cracks in castings are shown by radiographs, Figs. 16 and 17.

4.3 Cold shut appears as a distinct darkened line in bands of variable length and definite smooth outline.

Cold shuts are produced when two or more streams of molten metal flowing from different or similar directions fail to unite and form homogeneous metal. The basic cause for the occurrence of a cold shut is that the two bodies of molten metal which meet are at too low a temperature to join together. The surfaces of the cold shut may or may not be oxidized, depending on the magnitude of the defect. Cold shuts may be produced by interrupted pouring, slow pouring or the use of molten metal too low in temperature for the casting in question.

5. Miscellaneous

5.1 Surface irregularities are any image corresponding to an irregularity visible on the surface.

5.2 Misruns appear as prominent darkened areas of variable dimensions with a definite smooth outline.

Misruns are produced by the failure of molten metal to fill the section of a casting, leaving the region void, generally on account of pouring too cold metal.

The general principles and the diagnosis of various defects that may be found in steel castings by the use of the X-ray, having been discussed briefly, their application to a par-

Fig. 16 (Below)—Radiograph showing cold crack in casting.

This paper, dealing with the underlying principles of the radiographic process, was secured as part of the 1945 "Year-Round Foundry Congress" and is sponsored by the Steel Division of A.F.A. Part II of the paper, which discusses the application of the general principles of radiography to a production foundry, will appear in an early issue.

Fig. 17—Radiograph showing cold crack (light section) in casting.

ticular foundry will be discussed in Part II of the paper.

Acknowledgment

Acknowledgment is made to the personnel of the radiographic laboratories of the Granite City Plant, Indiana Harbor Plant and Cast Armor Plant of the American Steel Foundries for their assistance in preparing and selecting radiographs, to C. H. Walcher, Works Manager of the Granite City Plant, and to G. A. Lillieqvist, Research Director, for their assistance in preparing the manuscript.

Cost Committee Considers New Design Factors

THE A.F.A. Cost Committee has recently issued revised Recommendations to Buyers of Castings and urges that foundries who are contacting the buyers give consideration on the part of the designer to design factors which influence quality. In its publication containing the recommendations to buyers of castings it discusses many factors.

It is evident that much of a foundry's ability to produce castings of high quality depends upon the design of the casting. Appropriately, there is an increasing trend toward mutual consultation of user and producer of castings in matters pertaining to design. Examples of the benefits of this practice accruing to buyer and seller alike—and to the ultimate consumer as well—abound in the minds of interested persons and in the pages of an expanding literature of industry.

Improved understanding of the producers' problems, on the part of designers, and greater skill in meeting design requirements by the foundry are the inevitable results of such collaboration. The buyer, by soliciting the foundry's cooperation in this respect, takes an important step in improving the quality of the castings he receives, in improving the price he has to pay, and in increasing the ultimate economy of his product to its user.

While design considerations bear an important relation to quality and price, it is equally true that the foundry organization needs complete descriptions of the equipment with which it is to work, and accurate information pertaining to delivery requirements in order effectively to plan balanced production schedules, and intelligently to compute a reasonable price for doing the work involved. Experience has proven the advantage to user and producer of firmly indicated schedules, calling for delivery not in advance of actual requirements, and of adequate descriptions of the existing equipment intended to be furnished by the buyer.

The type of cooperation implied by all of the foregoing can only result in higher quality castings for the using organization, produced and delivered at a lower cost and in less time than would otherwise be possible. In order to summarize and make reference easier, a check list of information to be supplied with an inquiry for casting prices, together with a suggested form has been made.

Buyers of castings should use the list of essential information compiled by the committee when ordering to facilitate receiving an accurate estimate.

Surveys Removal of Wartime Controls Made

"POSTWAR Employment and the Removal of Wartime Controls" is the title of a booklet issued recently by the Research Committee of the Committee for Economic Development. The booklet, which constitutes a statement on national policy by the Committee, discusses the manner and timing of the removal of controls set up for industrial production during the war, and is the result of more than a year's study of this national problem.

Some of the subjects covered include Inflation and Deflation problems, Consumer Rationing, and recommendations of the Committee with regard to relaxation of controls on production, price, manpower and wages, exports and imports, and business financing.

Single copies of the report are available without charge from the Economic Development, Trade Association Div., 11 West 42nd St., New York 18. A small charge is made for the report in quantities.

Magnesium Foundry Film Available for Meetings

THE Hills-McCanna Company, Chicago, Ill., has recently developed a very interesting film on foundry production of "Magnesium, the Miracle Metal." This is available for showing before chapters, and any information regarding this film may be obtained by contacting D. W. Moll, vice president and treasurer, Hills-McCanna Co., 3025 North Western Ave., Chicago 18, Ill.

Increased Use of GRAY CAST IRON In High Temperature Operations

By C. O. Burgess, Metallurgical Engineer, Union Carbide & Carbon Research Laboratories, Niagara Falls, N. Y., and T. E. Barlow, Foundry Engineer, Battelle Memorial Institute, Columbus, Ohio

A SURVEY of the behavior of cast iron in elevated temperature applications has been made under authorization of the War Metallurgy Committee. Detailed information on 233 commercial applications of cast iron at temperatures over 450° F. was obtained from 99 concerns and 108 individuals. The resulting data show that within a temperature range of 450 to 1000° F., cast irons of controlled analysis can be successfully employed in numerous engineering applications. Included in these applications are castings which must resist pressure and be free from small dimensional changes.

Code Limitations

Codes limiting the use of cast iron to temperatures of 450° F. were established approximately 31 years ago, before modern cast irons of controlled structure and composition were in common use. These codes have prevented or discouraged the general use of cast iron in certain elevated temperature fields. Despite this limitation, research has continued and cast irons of controlled analysis have been developed that are structurally stable and resist deterioration at temperatures above 450° F. It is recommended that codes dealing with high temperature applications of cast iron be reviewed with the object of raising temperature limits in accordance with the demonstrated heat-resisting properties of existing grades of cast iron.

I. Introduction

Purpose

The present investigation and survey of the behavior of cast iron in elevated temperature engineering applications was undertaken by the War Metallurgy Committee at the request of the War Production Board with the purpose of determining whether the use of cast iron in such fields could be safely extended. A definite possibility existed that as a result of this survey the position of cast iron as an engineering material could be more sharply defined, and more strategic materials than cast iron might be conserved and procurement problems generally eased.

Background

The project appeared justified in view of several factors. These are briefly listed as follows:

(1) General use of cast iron at high temperatures has been limited by the existence of certain codes which specify that cast iron shall not be used at temperatures over 450° F. The principal specifications, A.S. M.E. Boiler Code Specification S-13, from which other codes, such as the Unfired Pressure Vessel Code, A.S.A. Standards, etc., appear to stem, was established in 1914, 31 years ago. Reference to the Boiler Code Committee did not reveal any definite experimental basis or specific data for fixing the limiting temperatures at 450° F., and a search of the literature indicated that the only material that might have influenced code action was an A.S.M.E. Symposium held in 1909, at which it was concluded that starting at a temperature of 450° F. certain cast irons deteriorated in structure and strength to a marked degree.

Chemical Analysis

As noted in greater detail in the original report, the importance of controlling the chemical analysis of cast iron was relatively unknown at the time of this symposium, and in the few cases in which analyses and tensile properties were recorded the irons were invariably of a high carbon equivalent (now known to be generally unsuitable for high temperature pressure applications). The tensile strength of the subject irons averaged 12,000 to 16,000 psi., em-

• Abstract of War Metallurgy Committee report, WPB Survey Project SP-512. It is believed to demonstrate convincingly the fact that with our modern understanding of the metallurgy involved and ability to apply the necessary controls, gray cast iron has taken its place as a dependable material for use in exacting engineering applications. This fact has for some time been recognized by foundrymen and engineers intimately concerned with the production or use of this material, but has not been so generally recognized by designing engineers less familiar with the developments that have taken place in cast iron metallurgy.

Table 1

Summary of High Temperature Applications of Cast Iron

Temp. Range, °F.	Destructive Factor	Applications — Successful	Applications — Unsuccessful	Applications — Total	Uses	Detailed Temp. Range, °F.	Press. Range, psi.	Life	Carbon Type	Carbon Equiv. $C + 0.3\,(Si + P)$	Alloys	Number Inoculated	Tensile Strength, psi.
451 to 600	Wear	33 (1 limited life)	0	33	Locomotive cyls., throttles, bull rings, valve boxes and bushings, steam pump cyls. and valves, Marine eng. cyls., oil pump cyls., liners, piston rings, valves, Diesel cyl. liners and pistons, aircraft piston rings.	30 at 500 or above. 8 at 600	90-1200 (22 at 200 to 300)	20,000 hr. for aircraft piston rings to 28 yr. for steam pumps. Piston rings only periodic replacement.	3 low 17 med. 8 high (old) 5 ?	3.5 to 3.9 except 8 old irons, 4.0-4.3, and Piston Rings, 4.6.	2—NiCr 1—CuMo 6—NiCrMo 1—MoNiCr	19	Modern type from 35 to 50,000 Old irons from 18 to 28,000
	Growth	15	9*	24	*Unsuccessful*—Steam valves and fittings, turbine casings and diaphragms made prior to 1920.	8 at 478 to 500 1 (600)	150 to 200	1 at 2 yr. (600° F.) 1 at 4 yr. 1 at 5 yr. 6 at 14 to 28 yr.	2 med. 4 high 3 ?	4.0-4.5	0	0	14 to 25,000 after service
					Successful — Marine engine manifolds, turbine casings, steam cyls. and diaphragms, steam chests, heat exchanger parts, locomotive steam parts.	18 at 500 or above. 3 at 600	40 to 300 (Av. 200)	New to 18 yr.—no failures.	4 low 8 med. 3 ?	3.5-3.9	1—Cu 2—NiCrMo 1—CuCrMo	8	All but 1 over 40,000 before service 2 from 33 to 35,000 after service
	Corrosion	11	0	11	Valves and fittings for crude oil.	8 over 580 2 at 600	No pressure	15 to 21 yr.—all still in use.	1 high 10 ?	Only 1 iron analyzed	1—Cr		?
	Erosion	26	0	26	Locomtive throttles, superheater headers, steam pump heads, valves and pistons, oil pump pistons, turbine control valves, Diesel engine heads and exhaust manifolds, blast furnace bells and explosion valves.	22 over 500 3 at 600	135 to 750	New to 23 yr.—all still in service.	2 low 19 med. 2 high 3 ?	3.5-3.8 except 2 old irons and 1 manifold at 4.0.	2—NiCrMo	20	35,000 min. with exception of 1 old iron at 27,000
601 to 750	Wear	26 (1 limited life)	0	26	Oil pump cyls., liners, piston valves, locomotive cyls., throttles, valves, valve chambers and cyl. bushings, steam engine cyls., Diesel cyls. and pistons, Marine engine cylinders.	22 at 650 or over, 14 at 700 or over	200 to 600	1 yr. replacement (bushing). Up to 50 yr. without failure.	8 low 12 med. 3 high 3 ?	3.6-3.9 except 3 at 4.0	2—Cr 1—Mo 1—CrMo 1—NiCr 2—NiCrMo 1—CuCrNi	15	30-45,000 Av. 40,000
	Growth	4	0	4	Turbine casings Autoclave inserts Resistance grids	2 at 650 1 at 720 1 at 750	200 ? 0	3 yr. 8 yr. 20 yr. } Still in operation.	2 low 1 ? 1 high	3.6-3.9 ? 4.3	(CuCrMo-NiCrMo) NiCr 1—Ni	0 ? 0	52,000 ? ?
	Corrosion	4 (1 limited life)	0	4	Locomotive steam pipes. Still trays and bubble caps.	4 over 700	1 at 225 3 at 0	3 over 10 yr. still in use. 1 fails by H_2SO_4.	3 med. 1 high	3 at 3.6 to 3.8 1 at 4.0	1—NiCr	1	Pressure 55,000 Nonpress. 30-35,000
	Erosion	18 (2 limited life)	0	18	Hot oil pump pistons, locomotive piping smoke box items, superheater headers and pistons, Diesel heads and pistons. Marine engine throttle valves, steam cyl. heads, bubble cap trays and spouts.	8 at 650 9 at 700 or above	200 to 275 3 no press.	New to 50 yr. without failure except trays and bubble caps fail 3-5 yr. from erosion and corrosion.	2 low 11 med. 5 ?	1 at 3.3 3.6-3.9	1—Cr 1—NiMo 2—NiCrMo	12	30 to 60,000 Av. 40,000
751 to 1000	Wear	2	0	2	Diesel exhaust valve seats and pistons.	900	?	Finally failed by wear or overloading.	1 low 1 high	? 3.9	1—CrMo 1—NiCr	1 ..	37,000 ..
	Growth	14 (2 have limited life)	0	14	Diesel exhaust valves, manifolds, furnace hangers, tuyeres and hearths, turbine valve stems, dryer heads and kettles, locomotive grate supports.	6 over 950 All over 800		8 from 5 to 15 yr. without failure. 2 replaced from 4000 hr. to 1 yr.	1 low 5 med. 5 high 3 ?	3.7-4.3	2—Cr 2—CuCr	6	30-45,000 Av. 36,000
	Corrosion	8 (2 have limited life)	0	8	Die casting equipment, lead and zinc pots, rabble arms, bubble trays.	6 at 800 to 850 1 at 900	3 from 500 to 2400 Others—0	Two limited life due to Zn and Pb—1-3 yr. Others from new to 10 yr.—no reported failures.	3 low 2 med. 2 high 1 ?	Press., 3.5-3.8 No press., 4-4.2	2—Cr 1—CuCr	4	Press. 40-50,000 Nonpress. 25-30,000
	Erosion	6 (1 limited life)	0	6	Pumps, oil valve bodies, Diesel piston heads, fuel nozzle bushings, Diesel exhaust manifold.	5 at 800 1 at 970	250-1000	1 limited. Others from new to 2 yr. without failures.	2 low 3 med. 1 high	3.4-3.8 except one at 4.2	1—CrMo	5	32-50,000
Over 1000	Wear	4 (all limited life)	0	4	Diesel bushing, liners and pistons, hot forming dies.	....	1 at 1000 3 high	Av. life 3 yr. 4000 to 10,000 parts per grind.	2 low 1 med. 1 high	3.4-3.8 3.5 4.1	(CrMo and CrMoNi) 1—CrMoCu 1—CrMoV	4	45-50,000 45,000 40,000
	Growth	13 (all limited)	1	14	Pipe covers, pots, furnace dampers, grates, trays, skid hearths, stools, retorts, exhaust manifolds.	....	No pressure	1 replaced by 30 Ni 18 Cr Longest life, 6 yr. Shortest life, 1 month.	9 low 3 med. 1 high 1 ?	3.5-4.0	4—Cr 5—CrCu 2—CrNi	13	6 at 50,000 4 at 30,000 4 ?
	Corrosion	14 (all limited)	0	14	Die casting equipment, melting pots, molds, furnace parts, cracking trays.	....	Die casting from 500-2000. Others, no pressure	From 30 days to 4 yr.	5 low 6 med. 3 high	Die, 3.6-3.8 Other, 3.6 to 4.3	2—Cr 2—CuCr 1—NiCr 1—Ni	12	Press. from 40-50,000 Nonpress. 25-50,000
	Erosion	15 (all limited)	0	15	Diesel cylinder heads, gas engine heads, hot blast valves, turbocharger rings, kiln parts, die castiig pots, dryers, furnace parts, ladles, glass molds.	....	3 from 25 to 1200. Others, no pressure	1 day to 3 yr. except gas engine heads which are still in operation after 25 yr., but are only at temp. for short periods.	5 low 5 med. 4 high 1 ?	Press., 3.4-3.8 Nonpress., 3.9-4.2	2—CrMo 1—Cu 3—NiCr 1—CrV 4—Cr 1—CuCrNi	9	Press. 38-50,000 Nonpress. from 30-50,000

*All made prior to 1920.

phasizing their inferior quality. It was found that the A.S.M.E. code has remained practically unaltered with regard to temperature limits since its inception, no cognizance having been taken of known advances in cast iron metallurgy since 1914.

(2) Committees interested in elevated temperature apparatus have already recognized the fact that with improvement in quality of cast iron, the safe maximum working temperature can be increased above 450° F. Evidence of this fact is the development of the proposed California Unfired Pressure Vessel Safety Orders recommending use of classes 20 and 25 irons at a maximum temperature of 450° F., class 30 irons at a maximum of 510° F., class 35 irons at a maximum of 575° F., and classes 40, 50 and 60 irons at a maximum of 650° F.

Applications

(3) Modern cast irons have been and are now being used in a number of engineering applications at temperatures considerably over 450° F. Obviously, certain cast irons must have been found satisfactory at such higher temperatures inasmuch as their use has been continued. However, no concerted effort has previously been made to obtain and correlate data on the general success or failure of cast irons in such high temperature applications.

(4) Many well-informed engineers in both the foundry industry and in consuming industries feel that the present code temperature limitation of 450° F. on cast iron can be safely increased. It was believed that by direct contact with these men and industries, sufficient service and experimental data might be uncovered to establish definitely the true top temperatures at which various types of cast iron can safely operate.

(5) The need for a review of the present code limitation temperature of 450° F. has been further evidenced by the recent formation of an American Foundrymen's Association Committee and a Subcommittee of A.S.T.M. Committee A-3 to study the use of cast iron at high temperatures.

In consideration of the foregoing factors, the present survey of actual applications of cast irons at elevated temperatures was immediately undertaken.

II. Factual Survey

The most significant part of the investigation is considered to be the factual survey of the success or failure of cast iron in existing high temperature applications. Specific data were obtained on 223 applications of cast iron at temperatures of over 450° F. from 99 concerns and 108 individuals, the great majority of such individuals being personally interviewed.

Forty per cent of the applications were furnished by consumers not engaged in cast iron manufacture, 30 per cent of the applications by consumer-producers, and 30 per cent of the applications by producers, or individuals connected in some manner with cast iron manufacture. The consumer-producer status was established in those cases in which cast iron constitutes a minor part of the manufactured product. For example, manufacturers of turbines and internal combustion engines who operate their own foundries were assigned this status.

The types of industries and associations included in the survey are as follows:

(1) Valve Industry
(2) Petroleum Refinery Equipment Industry
(3) Paper Industry
(4) Condenser Industry
(5) Pump Industry
(6) Furnace & Firebox Equipment Industry
(7) Power Industry
(8) Chemical Industry
(9) Alloy Producing Industry
(10) Foundry Industry & Consulting Engineers
(11) Steam Engine Industry
(12) Internal Combustion Engine Industry
(13) Army and Navy Bureaus
(14) Stoker Industry
(15) Foreign Associations (B.C.I.R.A.)

Information requested on each application included the type of casting, the analysis and method of manufacture, the temperature and service conditions to which it was exposed, the rate of failure, if any, the life of the casting, and whether it was considered successful by the consumer. Surprisingly complete information was obtained. For example, in only 39 instances, particularly of old applications, was information concerning chemical analysis completely lacking.

The data obtained are condensed in Table I. It will be noted that as a first step the applications have been empirically divided into four sections, in convenient steps of increasing temperature ranges in service. These four broad temperature ranges are 451 to 600° F., 601 to 750° F., 751 to 1000° F., and over 1001° F. The temperatures are further subdivided in the seventh column of Table I.

Second, the irons in each temperature range have been roughly classified into four groups, depending on the most probable major destruction factor; namely, wear, growth, corrosion and erosion. Obviously, either growth or mechanical deterioration from exposure to elevated temperatures could result in failure in any of these groups, but assuming that a given casting might exhibit satisfactory or indefinite life as concerns temperature effect, an estimate was made of the factor most likely to cause its final discard.

Classification

Under "Analysis," the irons in Table I were arbitrarily classified as to carbon type. They were considered "low carbon" when in the range of 2.7 to 3.1 per cent total carbon; "medium" in the range over 3.1 to 3.35 per cent total carbon; and "high carbon" if the carbon content exceeded 3.35 per cent. The most significant analysis factor related to the character and properties of unalloyed cast iron has been generally recognized as the carbon equivalent of the iron, *i.e.*, the total carbon content plus 0.3 of the sum of silicon plus phosphorus: per cent C + 0.3 (per cent Si + per cent P).

As a consequence, this value has been listed in the tables and plotted graphically in Figs. 1 and 2. It is recognized that any generalization of this type is open to exceptions, particularly when applied to extreme variations in chemical composition, but it appeared the most significant single factor in any summary treatment. The manganese in these irons generally was in the range 0.50 to 1.00 per cent, the phosphorus 0.40 per cent max., and the sulphur 0.12 per cent max.

Under "Remarks on Life" (Table I), it will be noted that a number of the applications have been in use for comparatively short periods, and obviously in these cases only the maximum life so far recorded could

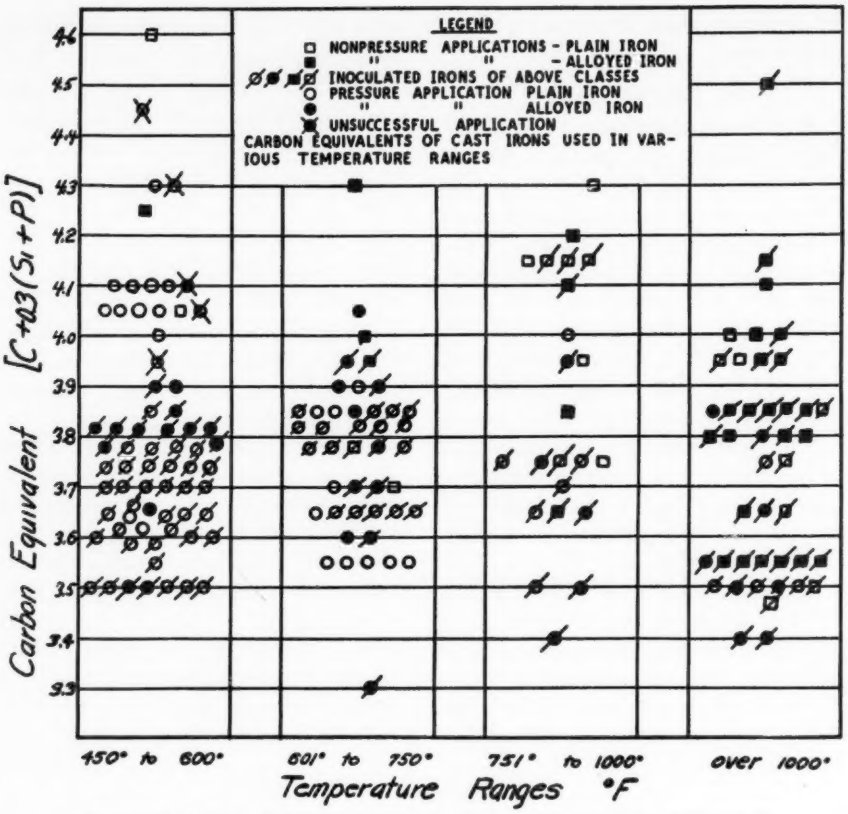


Fig. 1—Carbon equivalents of cast irons used in various temperature ranges.

be given, and a record of any failures within this period. The large number of new applications at temperatures of over 450° F. is of interest, showing that engineers are beginning to appreciate the possibilities of modern type cast irons.

Certain observations are immediately apparent from Table I and Figs. 1 and 2. In the 451 to 600° F. range, 94 applications are found, most of them involving pressure. Only nine failures are reported, and these all involve irons made before 1920 with medium or high carbon contents and with a carbon equivalent of 4.0 to 4.5 per cent. The successful applications, on the other hand, show a lower carbon equivalent of 3.5 to 3.9, with the exception of ten old type irons that run from 4.0 to 4.2 per cent.

There is a definite tendency in this temperature range, based presumably on experience, to make irons with low or medium carbon when they are intended for high temperature, pressure service. The life of the 85 successful irons extends up to 28 years, all being still in service except in the case of piston rings, which are periodically replaced because of wear.

In the 601 to 750° F. range, all 52 applications are considered successful, only four being periodically replaced due to corrosive action or excessive wear. The tendency to use low or medium-carbon irons having a carbon equivalent of 3.3 to 3.9 per cent is again evident, being most marked in applications involving pressure. Service life of up to 50 years has been reported.

In the 751 to 1000° F. range, all 30 applications are considered successful, although five have a limited life. In only one case (Diesel exhaust valves) can final failure be definitely assigned to growth or change in dimensions. Again there is a tendency to use low or medium-carbon irons, a carbon equivalent of 3.4 to 3.8 per cent being used in the case of castings that must resist pressure. Service life up to 15 years is reported.

Although this survey was directed primarily to applications operating under 1000° F., some 47 instances of the use of cast iron in excess of this temperature were reported. Forty-six applications were considered successful and one unsuccessful. In contrast to the lower temperature applications, the life at temperatures of 1000° F. or over was limited in all cases. In one case a life of one day was recorded, but the application was considered successful in view of the comparable behavior of competitive materials. The maximum life recorded for one application in this group was 6 years.

No continuous pressure was en-

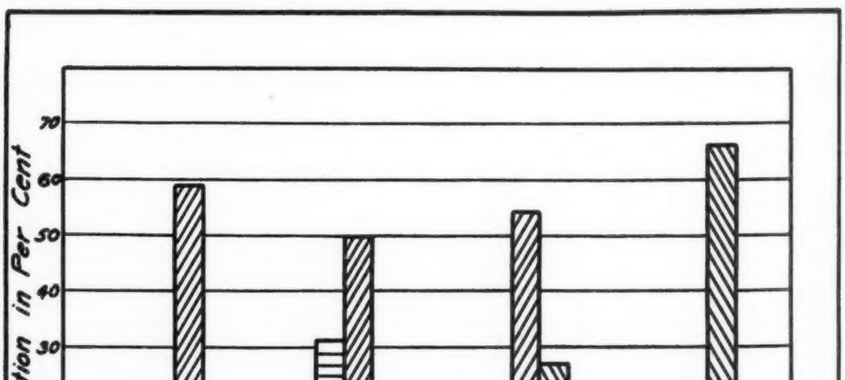


Fig. 2—Carbon equivalent distribution of irons used to resist pressure in various temperature ranges.

countered, but compressive loading existed in the case of hot-forming dies, die casting equipment, and Diesel parts with skin temperatures over 1000° F. When strength is a factor, there is again a tendency to use low or medium-carbon irons with a carbon equivalent range of 3.4 to 3.8 per cent.

Certain other observations are significant. With regard to tensile strength, virtually all of the modern irons in the 451-600° F. range have a minimum tensile strength of 35,000 psi., and most of the successful older irons possess a strength in excess of 30,000 psi. This also is true in the three other temperature ranges in which a definite tendency to hold modern irons to a 30,000 psi. minimum is apparent, with the average tensile strength approximately 40,000 psi.

Ladle Inoculation

A surprisingly large number of the cast irons investigated were inoculated in the ladle. Forty-seven of the 94 irons in the 451 to 600° F. range, 29 of 52 in the 601 to 750° F. range, 16 of 30 in the 751 to 1000° F. range, and 38 of 47 in the range over 1000° F. are known to have been ladle-treated. Thus, approximately 58 per cent of the total irons were subjected to some type of ladle inoculation. If the irons of unknown analysis are omitted, the inoculated irons constitute 73 per cent of the remainder. Various inoculants were employed.

With regard to the addition of special alloying elements, interest was mainly confined to low alloy gray cast irons, *i.e.*, irons containing a maximum of about 2.5 per cent of any special alloying agent. The special alloying elements included chromium, nickel, copper, molybdenum and vanadium, used either alone or in combination.

It can be noted from Table I that in the 451 to 600° F. range, 17 out of 94 irons are alloyed. In the 601 to 750° F. range, 17 out of 52 irons are alloyed. In the range 751 to 1000° F., 10 out of 30 are alloyed, and in the range of over 1000° F., 33 out of 47 irons are alloyed. Thus, about 34 per cent of the total irons are known to be alloyed. If irons of unknown analysis are eliminated, alloyed irons constitute 43 per cent of the remainder.

The tendency to employ low-alloy irons as temperature conditions become more severe is brought out in Fig. 3. Chromium is the most common alloying agent, appearing in 91 per cent of the alloyed irons, whereas nickel appears in 44 per cent, molybdenum in 39 per cent, copper in 23 per cent and vanadium in approximately 3 per cent of the alloyed irons.

In comparison with the above findings, information from the British Cast Iron Research Association is of interest in that, possibly due to wartime shortages or the fact that they did not differentiate between pressure and non-pressure applications, they appeared quite liberal in their permissible upper temperature limits.

According to British advices, ordinary cast iron may be used at temperatures up to 840° F. (450° C.), and an all-pearlitic, close-grained iron, preferably of a low-alloy type, may be safely used at temperatures up to 1020° F. (550° C.). If as much as 1 per cent of chromium can be incorporated in the iron, the upper temperature limit is raised to 1110° F. (600° C.). Low alloy iron is preferred to unalloyed iron for high temperature work, being considered more heat resistant, "partly as the irons are usually better made, more homogeneous, more uniform, and closer-grained."

Chromium carbide is stated to be particularly important as conferring stability, and if the amount of chromium is limited due to its tendency to make the iron white, nickel is recommended to permit further increase in chromium content, for example, in the ratio 3 Ni: 1 Cr.

III. Research Data on Behavior of Cast Iron at Elevated Temperatures

Considerable unpublished research data on the behavior of cast iron in the temperature range of 450 to 1000° F. were obtained in the course of the survey, and a summary of this information in conjunction with published data on the effect of high temperatures on the strength, growth, and structural stability of cast iron is included in the present report.

Strength

A large part of the laboratory information dealt with the short-time high temperature strength of cast irons varying in carbon equivalent from 3.6 to 4.5 per cent, and the test results showed no appreciable falling off in tensile strength up to 750° F. At temperatures above 1000° F., the tensile strength in general decreases rapidly.

Creep or long-time temperature tensile tests of cast iron are, of course, more significant, but data on such tests are limited. The available creep tests are reassuring, however,

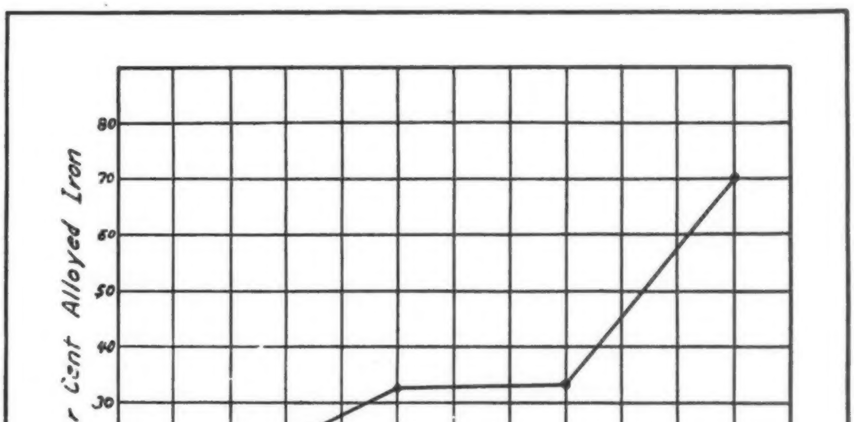


Fig. 3—Percentage of irons known to be alloyed in each of the various temperature ranges.

in that they demonstrate that ordinary cast iron (up to at least a carbon equivalent of 3.95 per cent) can resist loads of approximately 10,000 psi. at 750° F. without exceeding a creep rate of 1 per cent in 10,000 hours. The use of small percentages of alloying elements in cast iron has been found to increase materially the resistance to creep.

Before leaving the subject of the high temperature strength of cast iron, it should be observed that a critical exposure temperature exists for ordinary cast irons which, if exceeded, will produce a progressive loss in room temperature strength, due to such factors as growth, oxidation, and structural alteration. The minimum temperature at which such strength reduction may occur is a function of the structural stability or growth resistance of the particular iron, which according to evidence obtained in the survey is in turn a function of the carbon equivalent of unalloyed cast iron.

Superheated Steam

For example, records were found of iron castings subjected to superheated steam for extended periods at a temperature of 478 to 488° F. The irons having a carbon equivalent of 3.6 per cent exhibited an average strength of 33,000 psi. and a pearlitic structure after 14 years of such exposure, while castings with a carbon equivalent of 4.3 to 4.4 per cent showed an average strength of 16,200 psi. and a completely ferritic structure, and were removed because of growth after 10 and 14 years, respectively. Although the original strength of these irons was not determined, it is obvious that the irons of higher carbon equivalent have a dangerously low strength following their exposure, whereas the lower carbon equivalent irons have maintained a normal strength.

Data exist in the literature on tests made at temperatures in excess of 1000° F. which prove that additions of certain alloying elements also provide means of inhibiting or preventing strength loss. As little as 0.50 per cent chromium will materially reduce the loss in strength after exposure to a temperature of 1472° F., and at a 1.5 per cent chromium level no reduction in strength was observed in a gray iron after 500 hours' exposure to this temperature.

GROWTH

The tendency of certain cast irons to grow or permanently increase in dimensions on exposure to temperatures above a critical level is well known. The minimum temperature at which this phenomenon first appears is again a function of the structural stability of the particular iron. This growth phenomenon, besides producing dimensional changes, is also believed to lead to surface cracking and permanent strength loss, and thus often is the principal factor that leads to final failure of a casting at elevated temperatures.

Unfortunately for the purpose of this survey, most of the growth measurements have been made at temperatures of 900° F. or over. This is understandable in view of the fact that below this temperature the growth is very small in a given period of time, thus complicating the test procedure and greatly extending the necessary exposure time. However, considerable growth data at temperatures of over 900° F. have been accumulated and have demonstrated that unalloyed cast irons of low carbon equivalent are more resistant to growth than those of high carbon equivalent.

A number of general comments in regard to the character of these irons were received and are herewith summarized. Use of steel in the cupola mixture from which such irons are produced, insofar as it produces a more dense iron, apparently retards growth. Such low carbon equivalent irons are frequently subjected to ladle inoculation. Even small amounts of alloying agents, principally carbide stabilizers such as chromium, molybdenum, and vanadium, have been found to retard growth materially.

Comparative Growth Tests

Unpublished data relative to the specific effect of chromium on decreasing growth and stabilizing a pearlitic structure were received from several sources. In the comparative growth tests available, nickel and copper have been frequently and apparently effectively used in conjunction with the foregoing carbide stabilizers. It is obvious from the present survey that information of this type is being utilized to a considerable degree in the production of modern heat-resisting cast irons.

The difficulties inherent in tests directed toward determination of growth characteristics of cast irons at temperatures below 1000° F. are emphasized by the only research investigation of this type uncovered in the survey. In this test 36 unalloyed and low alloy cast iron bars ¾-in. in dimaeter and 21 to 23 in. long were submitted to superheated steam at 750° F. for periods varying from about 1 year to 995 days. In considering the resulting data, it should be first noted that the changes in length are generally minute, and consequently length changes brought about by stress relief and even by corrosion at room temperature may and apparently do seriously affect the growth readings.

Rate of Growth

However, assuming that all dimensional changes were due to growth, it is of interest that with one exception (a 0.15 per cent growth per year of a cast iron of 3.8 per cent carbon equivalent removed before completion of the test) all the irons with carbon equivalents of 3.95 per cent or under and tested in the "as-cast" condition or after an anneal not exceeding 1112° F. (600° F.), exhibit a total growth of less than 0.10 per cent a year *i.e.,* a length increase of 0.02 in. or less in 20 in.).

A majority show growth of under 0.05 per cent a year (a length increase of less than 0.01 in. in a 20-in. length during a one-year exposure). After certain periods, for example, 534 hours, 455 hours and 901 hours, respectively, in three different tests, the reported growth decreases rapidly to about one-half or less that reported in earlier periods.

Although length changes of such minute amounts do not permit accurate gauging of the effect of low alloy additions in these growth resistant irons, certain broad trends can be observed. For example, when the carbon equivalent exceeds approximately 4.0 per cent a very marked increase in the growth of unalloyed irons was recorded.

An unalloyed soft iron with a carbon equivalent of 4.14 per cent and exhibiting free ferrite as cast,

showed a growth in excess of 3.0 per cent a year, accompanied by marked internal oxidation. That such excessive growth can be materially reduced even in high carbon equivalent irons by additions of alloys, such as chromium and molybdenum, was evidenced by a drop to 0.25 per cent growth per year in an iron of 4.34 per cent carbon equivalent, containing 0.39 per cent chromium and 0.51 per cent molybdenum.

Annealing Temperatures

A second observation was that if unalloyed irons were annealed at temperatures of 1562 to 1607° F. (850 to 875° C.) previous to exposure to growth tests at 750° F., excessive growth took place despite an originally low carbon equivalent (3.48 per cent) and a previous record of excellent growth resistance in the as-cast condition. In this case the high annealing temperature caused the original structure to completely transform from pearlite to ferrite.

The only alloying agent used in conjunction with such high annealing temperatures was molybdenum, and in quantities of 0.35 to 1.0 per cent it appeared very materially to decrease the adverse effect of high annealing temperatures on growth resistance and to delay pearlite decomposition. Other carbide-stabilizing alloys, such as chromium and vanadium, would be expected to have a similar effect.

An obvious conclusion from the foregoing data is that the presence of ferrite in the structure of a cast iron, whether produced by using a high carbon equivalent or by annealing an iron of lower carbon equivalent, seriously lowers the ability of an iron to resist growth. The use of small amounts of alloying elements appears to counteract such increased tendency to grow insofar as they stabilize the pearlitic structure and prevent separation of ferrite.

In general, these tests indicate that dimensional changes of cast iron in superheated steam at 750° F. can be held to very low values by proper analysis control.

Thermal Shock

No direct research data on the resistance of cast iron to thermal shock were encountered during the present survey. The subject is introduced at this point, however, because several engineers contacted in the course of this survey expressed concern regarding this property of cast iron. There appeared to exist some uncertainty as to whether cast iron would withstand sharp thermal gradients through a given section to the same degree as steel, possibly due to a belief that thermal shock resistance may be associated in some manner with ductility exhibited in a tensile test.

Representatives of the valve and oil industry also inquired as to whether cast iron parts brought to a red heat due to accidental fire could be rapidly quenched with water or carbon dioxide without cracking. These inquiries suggest the possibility that failure of cast iron parts has occurred following such accidental fires, but no definite information on such occurrences could be obtained, or estimates as to the comparative resistance of alternate materials, such as steel, to a similar set of conditions.

Thermal Shock Resistance

On the subject of thermal shock resistance, it is known from the present survey, as well as from records of heat-treated parts, such as cylinder liners, that (1) cast iron parts can be successfully quenched from temperatures above the critical point; (2) that cast iron is successfully used in internal combustion engines, furnace parts, pots and molds in which sharp temperature gradients normally exist, and (3) that, more recently, cast iron has been adopted as tapping pots for molten metals heated to temperatures in excess of those used in steel manufacture. One contributor to the survey specifically stated that under temperature of 1000° F. he considered the thermal shock resistance of cast iron to be satisfactory inasmuch as he regularly heated castings of sharply varying section, such as cross heads, to 760° F., and quenched them in cold brine without ill effects.

However, information on the general subject of thermal shock resistance of cast iron is admittedly limited, and inherent shock resistance will no doubt vary, as in the case of steel, with the type of cast iron. In further investigation of the subject, it will be necessary to differentiate between failures due to thermal shock, and failures due to gradual development of growth cracks that may result from prolonged exposure of irons of unsuitable carbon equivalent to excessively high temperatures.

IV. Consumer and Producer Reaction to Use of Cast Irons at High Temperatures

In the course of the survey, opinions were obtained from manufacturers and users as to the desirability of employing cast iron at temperatures above 450° F. These reactions are an important part of the survey and hence are summarized here. In considering the following remarks, the difficulties and limitations attendant on crystallizing the diverse opinions of many men from different fields into a few paragraphs should be borne in mind.

It was found in the course of the survey that a surprising unanimity of opinion exists as to desirability of raising the present code temperature above 450° F. Differences of opinion were encountered as to the exact maximum temperature that should be established, the suggested safe working temperatures in the range of 550 to 800° F. The majority selected maximum safe working temperatures in the range of 600 to 750° F. In the few cases (four in all) in which the present code limitation of 450° F. was considered adequate, the individuals based their conclusions entirely on tests or experience dating at least 20 years or more ago.

In most cases these individuals qualified their remarks by stating that experience with modern or low alloy irons might alter their conclusions, but that such experience was lacking due to the existence of the present code limitation of 450° F. When an increase in the code temperature was recommended, it was almost invariably accompanied by the statement that some type of specification should be set up to assure the consumer that he was receiving an iron suitable for high temperature use.

Suggested Specifications

The suggested specifications included (1) establishing a minimum tensile strength for irons to be used within certain temperature ranges; (2) establishing a preferred chemical analysis with the purpose of controlling carbon equivalent; and

(3) establishing foundry requirements covering minimum percentages of steel to be used in the furnace charges, addition of special alloys and the use of ladle inoculation. By far the most commonly suggested specification was based on tensile strength alone, a minimum of 40,000 psi. usually being recommended for irons used at temperatures of 600° F. or above.

Alloyed Cast Irons

If an alloyed iron is employed, *i.e.*, an iron containing small amounts of one or more of the elements chromium, molybdenum or vanadium, or these elements in combination with nickel or copper, there is a general tendency among engineers to extend the allowable temperature limits above those employed for unalloyed irons. It will be recalled from information received from the British Cast Iron Research Association that this tendency also is evident in British practice.

It should not be assumed from the foregoing that problems specific to certain industries and not directly connected with high temperature resistance may not limit the use of cast iron. For example, in the oil industry, although successful use of cast iron valves and fittings at temperatures up to 800° F. is believed feasible and has, in fact, been practiced in several instances, doubt is felt as to the advisability of using this material in lines carrying hot oil under high pressure. Failure from thermal shock in case of a fire is considered to impose too great a risk.

In the valve industry opinion is divided as to the feasibility of using cast iron valves in certain industries, although all manufacturers believe the present temperature limit of 450° F. can be raised at least 100° F. when using controlled cast irons. Proper pipe layout, such as the use of ball-and-socket joints, "L" joints, or expansion joints to avoid excessive or uneven loading, is considered important when cast iron valves or fittings are employed.

High Strength Level

The advantages of holding cast irons to a high strength level in such applications are at once apparent. In valves where stresses in excess of the strength of cast iron structures may be encountered, and where it is important that eventual failure take place by distortion or bending rather than cracking, steel should be selected.

In steam applications, certain turbine manufacturers successfully employ high strength and low alloy cast irons for casings, diaphragms and steam chests at temperatures up to 650° F., although a more conservative attitude is exhibited by some of the larger manufacturers pending code changes. One producer, on the basis of tests reportedly made in France about 20 years ago, uses cast iron only in exhaust lines.

Steam Engines

Records of the behavior of steam engines, specifically of the locomotive type, proved to be one of the most fruitful sources of information. The universal and successful use of cast iron in such applications at temperatures as high as 750° F. and under 250 psi. constituted, in the opinion of many engineers, the best possible proof that the present low temperature limitation on cast iron is not justified.

Marine steam engines now employ cast iron at temperatures up to 650° F. and 240 psi., and no difficulty has been reported from its use. The sections employed are rather heavy, but no marked or destructive growth has been experienced. The data are sufficiently conclusive to have resulted in recent marked liberalization of the attitude of government agencies towards the use of cast iron in high temperature marine propulsion engines.

Internal Combustion Engines

In the case of internal combustion engines, a very liberal attitude was evident regarding the use of cast iron. Cast iron parts operating at temperatures of 1000° F. and with skin temperatures exceeding this figure were encountered, and parts operating continuously at temperatures up to 750° F. were common. Many of these parts show marked temperature gradients since they are usually water cooled. No growth or trouble was reported by the manufacturer during the expected life of the engine except from accidental factors, such as overloading.

Foundrymen associated with foundries capable of producing controlled cast irons were generally of the belief, based on reports of consumers, that the temperature limitation could be safely increased to at least 650° F. They expressed full confidence in their ability to produce, regularly, irons to meet such temperature conditions.

V. Conclusions

(1) Successful use of cast iron of controlled analysis in a wide variety of temperature applications demonstrates that there is no justification for continuing the present arbitrary temperature limitation of 450° F. for all cast irons, as originally established by the A.S.M.E. Code Committee in 1914.

(2) It is evident from the record of 233 applications above 450° F. that cast irons of controlled analysis can be safely employed in many pressure applications at temperatures considerably in excess of 450° F.

(3) From the survey record, it is evident that cast iron parts of controlled analysis are being successfully used in pressure applications at temperatures as high as 750° F. with indefinite life, or with a life limited by other factors than heat resistance.

(4) Out of the 233 applications on which records could be obtained, only nine failures due to heat effects were reported. Each of these nine failures is limited to cast irons made prior to 1920, and in all of the cases in which analyses of the unsuccessful irons are known, the carbon equivalent, per cent C + 0.3 (per cent Si + per cent P), was found to be 4.0 per cent or above. A number of castings showed limited life as the service temperature exceeded 750° F., but were considered successful by the users inasmuch as final failure was reported to be due to factors not connected with the inherent heat resistance of cast iron.

High Temperature Pressure Applications

(5) In the production of cast irons for high temperature pressure applications, a definite tendency has been shown to hold the total carbon content to a low or medium value (2.7 to 3.35 per cent) and the carbon equivalent in the range of 3.4 to 3.9 per cent. The majority of successful applications were made from cast irons lying within this analysis range.

(6) It is evident from the recorded failures and existing research findings that unalloyed open-grained

irons of a carbon equivalent of 4.0 per cent or above are normally not suited for high temperature pressure or steam applications.

(7) From the survey records, it is evident that for successful heat resistance it is advisable to hold the tensile strength of cast irons to a minimum of 35,000 psi., with the average minimum tensile strength approximating 40,000 psi.

(8) Ladle inoculation is widely employed in irons used for high temperature applications. At least 58 per cent of the irons covered in the survey are known to have received some type of ladle inoculation.

Low Alloy Cast Irons

(9) About 34 per cent of the irons covered in the survey are of the low-alloy type, *i.e.,* they have received small additions (up to 2.5 per cent) of one or more of the elements chromium, nickel, copper, molybdenum, and vanadium. The number of alloyed irons increases with the severity of the temperature conditions. Chromium is the most common alloying element, appearing in 91 per cent of the alloyed irons.

(10) Records of experimental work received in the course of the survey show that in "short-time" tensile tests the normal strength of cast iron is maintained up to a temperature of at least 750° F. Available creep test data indicate that cast iron (up to at least a carbon equivalent of 3.9 per cent) can resist loads of approximately 10,000 psi. at 750° F. without exceeding a creep rate of 1 per cent in 10,000 hours.

(11) Records of research work and service exposure tests indicate that the presence of free ferrite in an alloyed iron (whether the ferrite is produced as cast by using a high carbon equivalent or produced by annealing an iron of lower carbon equivalent) seriously lowers the ability of an iron to resist growth.

Chromium Additions

(12) Unpublished research records from several sources were received in the course of the survey with reference to the effect of small chromium additions on decreasing growth. The use of chromium as well as other alloying elements, either alone or conjointly, is recommended by these contributors. These findings are in accord with published information, and the use of small amounts of alloying elements in cast iron would, therefore, appear advisable, at least to the extent that they stabilize a pearlitic structure and minimize separation of free ferrite.

VI. Recommendations

The authors of the present report have been asked to offer general recommendations on the basis of material received in the course of the survey and interviews held with producers and consumers. However, it is realized that no attempt should be made to usurp the functions of code bodies whose legitimate business it is to fix allowable temperature limits and determine specifications.

It can be stated, solely on the basis of the factual survey, that cast irons of controlled analysis can be and are successfully employed in commercial pressure applications at temperatures up to at least 750° F. On the basis of research findings, such irons also retain a large proportion of their strength and structural stability up to this temperature. In view of these findings, the present arbitrary limiting temperature of 450° F. set by the A.S.M.E. Boiler Code and other code bodies for all cast irons irrespective of type, does not appear justifiable.

It is recommended that any cast iron intended for high temperature applications be required to meet definite specifications. On the basis of this survey, unalloyed or low-alloy cast irons normally should be of low or medium carbon content, and possess a maximum carbon equivalent of about 3.9 per cent. Use of carbon equivalents above this maximum would appear to be justified only in the case of highly alloyed irons.

Ladle inoculation enters this picture insofar as it will beneficiate the structures obtained with low carbon equivalent irons. The cast irons should be required to meet a minimum tensile specification; for example, 35,000 psi. in the case of irons used in the neighborhood of 450° F., and progressively stronger irons for use at higher temperatures. The belief that tensile strength can be used as a major criterion is widespread, as evidenced by the proposed California Unfired Pressure Vessel Safety Orders and the reactions of many individuals contacted in the course of the survey.

The use of small percentages of added alloying elements that stabilize a pearlitic structure appears advisable under severe temperature conditions, or to assure heat resistance in critical applications.

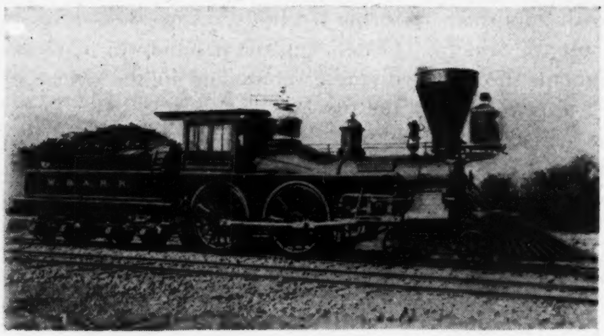
The information obtained indicated that the use of cast iron can be safely extended in high temperature fields. However, the authors strongly feel that on the basis of this survey, cast iron should not be promiscuously substituted for other materials. Each installation should be carefully reviewed to be sure that some property other than heat resistance may not be the final determining factor.

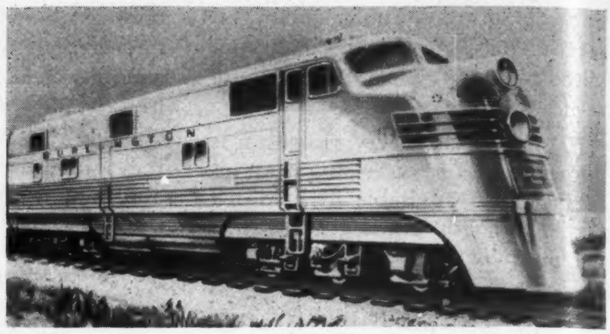
Book Review

Industrial Electric Furnaces and Appliances, Vol. I, by V. Paschkis. Cloth bound, 232 pages, 128 figures. Published by Interscience Publishers, Inc., New York. Price, $4.90.

At the present time the electric furnace industry, experiencing a renewed impetus, is faced with new problems, resulting from changes in industrial heating practice. In solving these problems, the designer will be forced to think in terms of uniform heat transfer to and from the product to be heated, as well as in terms of comparative heat sources and temperature control. Realizing the designer's need for an accurate knowledge of fundamentals, as well as a familiarity with experience of the past, the author has prepared this exposition of the principles of electric furnace design and operation, emphasizing thermal aspects.

In the preface, the author has effectively summarized the contents of the book as follows: "The book is planned in two volumes. In a general chapter, the first volume covers the thermal, electric, and economic principles applying to all types of furnaces and appliances. A second chapter discusses arc furnaces and electrode melting furnaces; here, emphasis is placed on steel melting furnace. The second volume will cover induction, capacitance, and resistance heating."





Two types of passenger locomotives are shown above. The extreme differences are quite apparent. Will the locomotive of tomorrow require more castings or will plastics, welding, metal stampings, forgings or powder metallurgy play a larger part than normally?

The POST-WAR Outlook for the Foundry Industry

By E. F. Platt,
Castings Buyer, Sperry Gyroscope Co., Brooklyn, N. Y.

• ***This paper, while recognizing the technical advances and war production records of the foundries, emphasizes the need for intelligent cooperation within the industry to meet the problems of post-war competition.***

DURING 1943 Arthur J. Tuscany, Executive Secretary, Foundry Equipment Manufacturers Association, made the following statement: "The foundries of this country have made a much larger contribution to the war effort than they themselves appreciate or realize."

In the Dec. 1944 issue of *The Foundry,* the editor discussed the excellent record established by foundries during the first year of the war, and concluded with the statement that "an industry which has been able to establish such a fine record should render even greater service in the days to come."

For the purpose of comparison, a few examples of some of the things which have recently confronted foundry operators should be mentioned.

During the time it has been the author's pleasure to serve on the A.F.A. Inspection of Castings Committee, he has come to recognize that buyers of castings, as well as foundries, have their shortcomings. The author should like everyone to understand that, as far as he is concerned (and he is sure that other buyers of castings feel likewise), anything which can be done to bring about closer cooperation between foundries and buyers of castings, in the trying days ahead, will be carefully considered by the members of this Committee.

Foundry Reconversion Period

It would be presumptuous for any individual to attempt to answer even some of the many questions which are being asked from day to day as to the future for the foundry industry. Nevertheless, the shape of things to come is, to the author's eyes, clearly evident.

The dedication of practically our country's entire industrial machine to the prosecution of the war is now complete. Even with the shift of things required by our armed forces of various and sundry types, there is an obvious lag. No one knows how long the accent on war manufacture will continue any more than anyone knows when the war will end. However, we can feel reasonable sure of one thing and that is, when the war does end (and it is sincerely hoped that that day is not far off), a reconversion period will confront all of us.

The author is one who feels that it will not take much more time to reconvert than it did to get under way for war manufacture. The pressure of civilian requirements is likely to be great, although of a different character.

We know now that the nation at large is going to be starved for machines and gadgets of all types. Our transportation system, from railroads to automobiles, will be pretty well worn out. And we suspect that every man returning from service in our armed forces will want to get aboard something and go some place.

It seems logical to expect that the automobile industry will reconvert first, with probably little immediate change in their first models. They will probably make use of their old machine tools and start manufactur-

ing early in order to satisfy the appetite for new orders. The same thing will apply to thousands of machines, such as refrigerators, vacuum cleaners, washing machines, furnaces, kitchen equipment, etc., and private utilities are going to need pumps, pipes, turbines, generators, and no end of other equipment.

Agricultural Machines Needed

Last, but by no means least, our farm trade will need new agricultural machines in untold quantities. Summing all this up, the outlook for the foundry industry, to say the least, is encouraging. There will be demands for all types of goods. Large interests will have huge plants and increased funds.

The demands for repair parts for all types of machines will be noticeable, and this latter demand could have the effect of shifting more of this business out of the foundries that will be required to run full capacity on new work.

Now, here is an important point—in the foundry industry, we shall see a very large increase in the capacity for manufacturing light, non-ferrous castings. However, among competing industries, there will be a large capacity for producing forgings. Plastics in many forms will be offered, and the new combination of wood and plastics will prove to be more competition for foundries.

All of the government training which has been under way during this war, and which makes "Winnie" a welder in two months, has given a lot of good publicity to the welding process, and the emphasis on aircraft, where welding and pressing has predominated, has undoubtedly made its impression on the working public as well as on the designers.

Foundry Merchandising

The fact that casting manufacturers have done an outstanding job during this war is recognized and, we believe, understood. Some of the things being done with castings today were unbelievable a few years ago. However, on the matter of merchandising its products, the foundry industry, as a whole, is so far behind that it is not even funny. During this war, the foundry industry needed to give little attention to the matter of seeking buyers. The buyers, it seemed, sought the foundries.

That may be one reason why casting manufacturers have been so reluctant to really sell and produce on anything like the plane that other industries have. The author is convinced that an industry which has shown the progress and accomplishment in methods of production, both scientific and technical, that the foundry industry has achieved, can, if it will, do an outstanding job of merchandising its product.

Industry Cooperation

Whether or not this is possible cooperatively throughout the entire foundry industry, we are not prepared to say. Experience seems to indicate that it has been impossible.

This paper was secured as part of the Program for the 1945 "Year-Round Foundry Congress" and is sponsored by the Inspection of Castings Committee of A.F.A.

If such is the case and it is impossible, then let the various branches start at once toward the desired goal by doing the job individually but to the point of refraining from casting aspersions within the foundry camp.

There is too much to be done, if we are to catch up with welding, stampings, and other competitive constructions, to waste energy by swinging on one another within our own industry.

Future Planning

Until just recently, it was considered rather unpatriotic to think of planning for the future. Our job, as manufacturers, was definitely indicated to us to keep producing everything necessary to speed the day when the United Nations could successfully conclude this war. We were persuaded to forget future planning and thinking. Recently, however, there has come a change in this direction. It is now once again respectable for manufacturers to engage in the necessary practice of planning for the future.

It is interesting to note, in passing, that politicians, social reformers, farmers, labor unions, and other groups have been planning plenty all during this war effort, and are continuing to do so today. Consider this thought: if the foundry industry does not do some planning of its own and have some things ready to present for itself, it may find that others have undertaken to do the job for it.

The specific problems which, to the author's mind, concern the foundry industry today are the selfsame problems which have confront it in the past. Either we solve these problems or we disintegrate. Each one of these problems could be answered by intelligent and cooperative effort on the part of the entire industry by doing a more constructive job with recognition of certain outstanding needs and in the determination of these needs through joint action.

Successful Foundry Organized

It is very simple to see that whereever we find a successful foundry, we find an organization which has done two things: improved its product to the highest degree possible and then set out to do a really constructive merchandising job. The lesson is obvious. It is possible to stimulate demand by making known the desirable features in a product. And it is possible to gain a position of national leadership through concerted, unified action.

The story of what American industry has done through cooperative action during this war is one of the most fascinating, as well as satisfying, pages in the industrial history of our country.

Converting peace time factories and organizations into arsenals of war shows the initiative and ability of American engineering minds. Our success on land, sea and air has been due to a cooperative spirit between all industries. One thought in everyone's mind being to win the war first.

Editor's Note: Readers of Mr. Platt's article might be interested in reading A.F.A. President Ralph J. Teetor's story which can be found on page 32. An interesting parallel can be drawn between the two contributions as one author is a castings buyer while the other is a castings producer.

SAE War Engineering Board Report

Shop Procedure for Repairing Apparent Imperfections in New Automotive Gray Iron Castings

At the request of the chief of ordnance, Detroit, an industry committee including representatives of the American Foundrymen's Association and the American Welding Society was appointed by the SAE War Engineering Board to review and recommend changes in OCO-D Engineering Bulletin No. 152, and to prepare a recommended shop procedure for repairing apparent imperfections in new automotive gray iron castings.

The revised Engineering Bulletin No. 152 and the shop procedure, which are part of this report are the approved recommendations of the SAE War Engineering Board and the Ordnance office.

THE purpose of Engineering Bulletin No. 152 and revisions and also of this paper is manifold: To facilitate legitimate production by outlining repair practices which are approved as satisfactory from a quality viewpoint; to indicate unsatisfactory practices and explain them in detail; to provide an urge toward improvement of casting quality by frank discussion of defects existing and means for repairing them; and to avoid misunderstandings as to quality levels between foundries producing castings, fabricators processing them and armed services procuring them as finished products.

Gas and Arc Welding

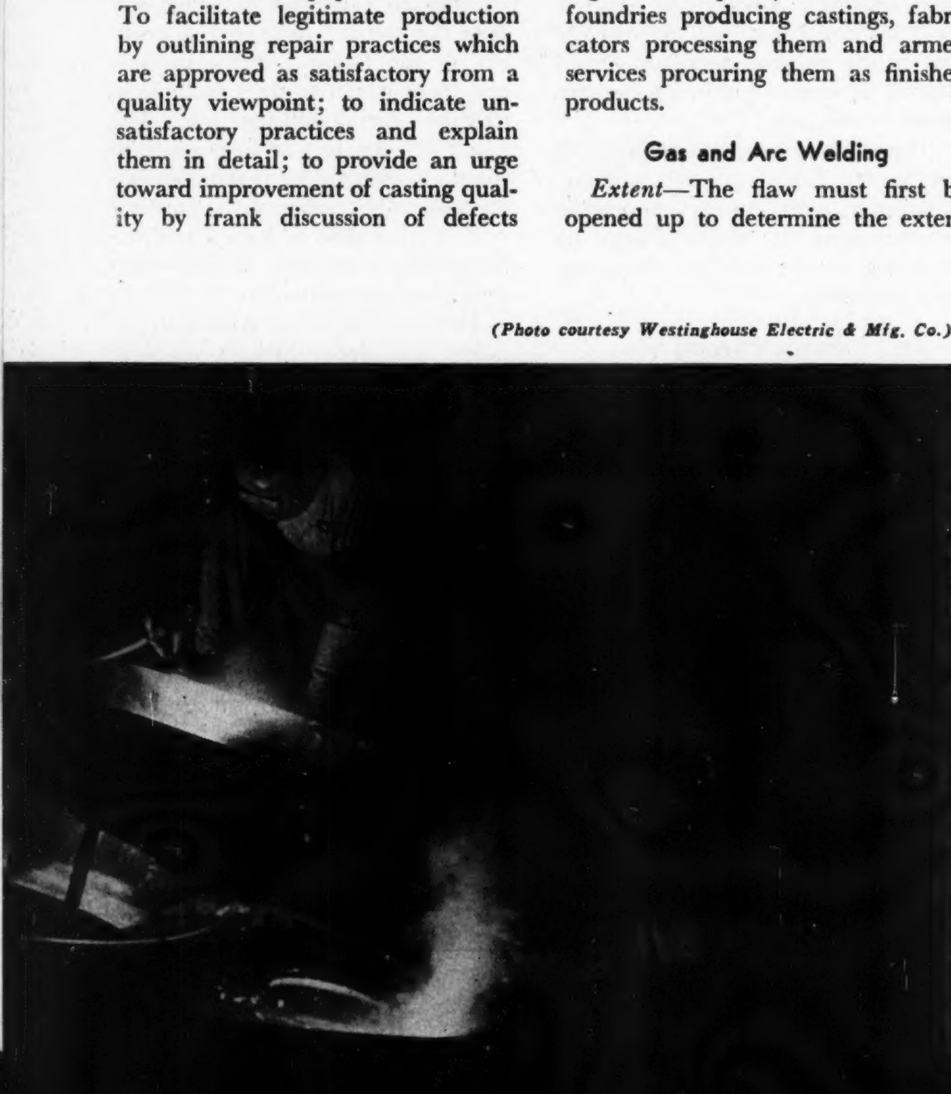
Extent—The flaw must first be opened up to determine the extent of the defect. This will depend upon the nature of the defect, whether it is a misrun or underfill, a coldshut or lap, a crack, broken-out section, machined off dimension, drop, scab, rat, crush, mismatch or shift, etc., as each sort of defect has typical extents and variations.

Only after opening up and/or determining the extent of the defect can it be judged as to whether or not it is repairable. The type of the defect is not important except as it governs the extent of the repair to be made after the defect is completely removed.

Preparation — The defect and adjacent areas must be thoroughly cleaned out before welding is started. This would best be done by flame gouging after preheating, carefully and properly applied, *i.e.,* so as to show by the change in color and flash of the flame that the defective areas are completely removed. In order to be sure the defect is all removed, unless the operator has a high degree of skill with the torch and is thus able to tell when the defect is all burned out by the flame ceasing to flash and the dulling down of the color of the flame, it is advisable to use one of the generally accepted inspection methods, such as kerosene, or mineral spirits and chalk, black light and fluorescent oil inspection, acid ething test, magnetic particle inspection, to be sure the defective area is completely removed.

If chipping is used, great care must be exercised to be sure defect is all removed, as chipping tends to hide the defect. The preferable chipping procedure is to rough chip, then complete cleaning by grinding, particularly if crushes or scabs are present. Sand or grit blasting may be used for mild cleaning, but cannot be depended upon for dirty or burnt-

(Photo courtesy Westinghouse Electric & Mfg. Co.)



in areas. When cleaning out of cracks is done by chipping, grinding or other mechanical methods, one of the above mentioned inspection methods should be used to make sure the defect is all removed.

In some cases where cracks are to be repaired, small holes are drilled beyond the ends of the cracks, which are then ground out from drilled hole to drilled hole. If the drilled holes are not *beyond* the ends of the cracks, the cracks will propagate under welding heat; so great care must be taken to insure getting drilled holes beyond ends of cracks.

Preheat—The casting must be preheated slowly and uniformly up to between 900 and 1100° F. before welding, in the case of plain iron. In the case of high strength iron, the range will be 1050 to 1250° F. The preheat temperature should not exceed 50° below the critical temperature of the metal, which is determined by the analysis of the casting involved.

Castings and Furnace Cold

The casting and the furnace should both start cold together, whether a batch or continuous furnace is used. The starting temperature as shown on the furnace pyrometer should not be over 350° F. when the fire comes on, although in batch furnace practice, heavy castings may be charged into a furnace when the pyrometer shows 600 to 800° F. At the same time, it must be realized that thin sections or delicate castings may crack with sudden application of high heat. Great care must be taken to insure that castings are heated so as not to cause too great stresses by thermal shock.

Welding — Welding should start immediately after removal from the furnace and the welding time should be held to the minimum. In the case of either arc or gas welding, instructions to the operators should emphasize that speed is essential to quality. The temperature of the casting during welding should not be allowed to drop below 700° F. Certain castings will require an even higher minimum than this, and under some circumstances it may be desirable to apply auxiliary heat during welding. Here, as in preheating, great pains must be taken to keep the heat in the casting up high enough to prevent damage to the casting. Spot-welding temperatures are best checked with a contact thermocouple pyrometer or a total radiation pyrometer. Temperature indicating pellets, crayons, paints, or fusible alloy can also be used to check temperatures to which castings drop.

Rod or Electrode—Rod or electrode should preferably be of gray iron of such a nature that the weld has a structure and hardness comparable to those of the parent metal. For arc welding (and some torch welding) flux-coated cast iron electrodes are used. Weld deposit in all cases should be uniformly sound metal and readily machinable.

Flux—In the case of gas welding, a suitable flux must be used. The flux should provide adequate flotation, fluidity, or puddling, so that the welds are sound and free of slag or gas inclusions.

Post Heat — The post heating of castings for stress relief should be done at 1000 to 1100° F. for plain iron. The temperature range should be determined by the metal analysis for high strength iron. The post heating temperature should not exceed 50° F. below the critical temperature of the iron. Castings must be cooled very slowly. In a continuous furnace, castings should be cooled to 700° F. maximum before removal and preferably should be carried much lower. In case there are no furnace cooling provisions, castings should be buried in powdered silocel, asbestos, lime, sand, charcoal, mica, crushed slag, etc., for heat insulation to ensure slow cooling.

Nickel Welding ("Cold Welding")

Bore Welding

Extent—The flaw must be opened up to determine its extent. No leaky bores will be nickel welded.

Limits—If the cavity, after cleaning out the defect, is greater than 3/16-in. in diameter in the ring travel or 5/16-in. in diameter outside the ring travel or extends through more than one-half the machined thickness of the well involved, it shall be considered unrepairable.

Preparation — The cavity resulting from removal of the flaw should be absolutely clean and, while chipping may be used, this cleaning usually can better be done with a right angle drill, flexible shaft and rotary file, or similar equipment.

Preheat—No preheat is used.

Electrode — Ninety-four per cent nickel bare wire of not greater than 5/32-in. diameter is used.

Welder—The welding transformer should provide low voltage (6 to 12 volts) with high heat (approximately 350 amps.) such that the nickel is melted and is scratched off the wire while in a plastic form. No continuous arc is held, as this would result in a hard heat affected zone. This welding operation should be performed by an operator of considerable experience, or one who has demonstrated his ability with samples which are cut and examined for hardness and bond.

Post Heat — No post heating is necessary.

Dressing—After the weld has been completed, it should be smoothed off with a small grinding wheel and the bore re-honed.

General Nickel Welding

This type of welding is performed in conjunction with a standard arc welding machine, using as low amperage as is consistent with sound deposits; and every effort should be made to hold down the heat in the casting to a minimum. This method is for the purpose of furnishing sound deposits to repair small defects in non-critical areas of machined castings. It is used where subsequent machining or tapping is necessary.

There is also a process called Intermittent Welding, which is performed by means of a technique utilizing high amperage and resulting in an intermittent arc, thus lessening the tendency toward excessive heat accumulation, which latter causes hard heat affected areas.

Extent—The flaw must be cleaned out to determine the extent of the defect. While the size of the defect which may be repaired by this method is limited to minor defects, it is not so limited as that listed under nickel welding.

Preparation—Flaw must be thoroughly cleaned by chipping, grinding or machining.

Preheat—No preheat is used.

Electrode—The arc welding electrode used is a coated type of commercially pure nickel or monel metal,

and should not exceed 5/32-in. diameter.

Welding—(See introductory paragraph on general nickel welding.)

Post Heat—No post heat is used.

Dressing—After the weld is completed, it should be dressed with a small grinding wheel, or subsequently machined.

Special Repair Conditions

Gas Welding with Local Preheat and Post Heat

Gas welding with local preheat and post heat, on semi-finished castings, is permissible under special conditions. When this operation is done correctly, the heat affected zones are not critical; but this type of welding should be used only where there is no danger of affecting the important areas of the castings. It should be attempted only by an expert welder and then only on corners, curved areas, or on such places where expansion and contraction are not restricted.

Extent—Same as under gas and arc welding.

Preparation—Same as under gas and arc welding.

Preheat — The area immediately surrounding the repair should be preheated to a dull red heat (in a dark location) or approximately 1000° F., by means of the gas welding torch, immediately prior to welding.

Welding—The welding procedure should conform to that described under gas and arc welding.

Rod — Similar to that described under gas and arc welding.

Flux—As described under gas and arc welding.

Post Heat — There is no actual post-heating in this type of welding. However, after the weld has been completed, the operator should continue to play his flame on the area around the repair in a gradually diminishing manner over a period of several minutes (depending on the section being repaired), to provide slow cooling through the critical range (see gas and arc welding, extent and post heat).

General — Only the most expert welders should be permitted to do this type of welding; and every precaution should be taken to insure uniformly good results. Samples should be cut and checked for hardness and microstructure before allowing this type of repair. Continuing repeat checks should be made at short intervals to demonstrate both the operators' skills and the process being used. The hardness and microstructure of the repair should approximate that of the parent casting (see gas and arc welding, rod or electrode).

Brazing

Brazing with gas torch heat utilizes almost the same procedure as outlined in general nickel welding, extent, gas welding with local preheat and post heat, with the exception of the filler material used. A Tobin brass rod is generally used for the deposited metal, which will be stronger and harder than the nickel repair previously described. This method can be used for the repair of minor defects in such locations as bearing seat covers, locating pads, etc. A special cast iron brazing flux should be used.

Silver Brazing

Hard silver solder and other similar materials should only be considered for individual cases requiring special treatment. In these cases the procedure should be worked out and approved for the particular casting involved. This class of repair covers a great many widely divergent patented materials with entirely different procedures of application. Suppliers of these materials should be consulted for proper procedures, in case of their use.

Cast Iron Soldering

Using the proper type of solder (such as 97.6 per cent zinc, balance copper, melting point approximately 700° F.) and flux, soldering is permissible for the repair of gasket faces or other small machined surfaces showing defects where structural strength or high temperature is not involved. Strong, uncut hydrochloric acid should be used for soldering flux and a soldering copper at dull red heat is the preferable method of applying the solder. This solder is harder than ordinary tin-lead solder and melts at a much higher temperature. Such repairs may be finished by filing, machining, or grinding.

Mechanical Repairs

Plugs or bushings are permissible to repair leaky areas which are subject to compressive stresses or low tensile stresses. Plugs should be of gray cast iron of approximately the same hardness as the parent material, should be taper threaded (SAE Dryseal American Standard Pipe Threads, pages 605-622, SAE 1944 Handbook) and so used as to have at least three threads engagement as finished. They should be inserted after coating both male and female members with a litharge—glycerine sealer. Bolt boss bushings should be so designed as to transmit bolt compressive loads on shoulders adequate in size to carry loads without creeping. Bushings should be so fitted as to be leak tight to pressure test after assembly and sealing.

Peening Repairs

The use of round-nosed, either hemispherical or semi-cylindrical peening tools and power hammers should be confined to weepers or seepers and should not be attempted for leakers, as above defined. Where leaks exist beyond the weeper or

seeper stage, peening repairs should not be attempted.

Sealing Repairs

Use of polymerizing resin sealers for leakers beyond the category of weepers or seepers, where the test water under pressure comes through in a fine misty spray and not in a solid stream, is satisfactory when the casting cavity is filled with liquid sealer, and a pressure of at least 50 lbs. per sq. in. is applied to force the sealer into the leaks, and the sealer is drained and the casting baked at sufficient temperature and time to thoroughly polymerize the sealer. Only those sealers may be used which, after polymerization, resist the action of water, alcohol anti-freeze, glycerine anti-freeze, ethylene-glycol anti-freeze, cooling system corrosion inhibitor, gasoline, lubricating oil, trichlorethylene, Stoddard solvent, kerosene, or other anti-freeze, corrosion inhibitors, or cooling system cleaners as are approved by the Procuring Services.

Rusting Repairs

The use of sal-ammoniac for rusting up seepers or weepers should be done only by dissolving approximately 10 per cent sal-ammoniac in the pressure leak test water and forcing the sal-ammoniac-water solution into the porous areas under pressure of from 65 to 100 lbs. per sq. in. Sal-ammoniac should never be used by being placed on or in castings in high concentration and without pressure. Use of sal-ammoniac should not be permitted for leakers beyond the category of seepeers or weepers (where liquid comes through under test pressure at the rate of not over two drops per second).

Committee Reports

Malleable Foundries Produce for War

By Chairman A. M. Fulton, Northern Malleable Iron Co., St. Paul, Minn.

THE Malleable Iron Division, American Foundrymen's Association, still continues its activities in the production of parts for the various needs of the war effort.

The Industry has been producing large quantities of high quality castings for the especially extended motor truck division program and other armament divisions for the armed forces.

The purpose of this division is to present to its membership, contributions on the development in the art, not alone from the technical but also the practical side, so that they can be applied in the production of better castings. Further, through the local A.F.A. chapters at their monthly meetings, papers are presented which create free discussion from the floor, thereby aiding in the presentation of useful knowledge to the malleable foundrymen.

At the 1944 Convention in Buffalo, a fund of valuable information was presented in the form of a "Symposium" on gating and heading malleable iron castings. This "Symposium" will be referred to often by our members as a guide in solving their problems.

Never has manpower been more important than today. The effectiveness of this manpower can be increased by attendance and participation in the activities of your local A.F.A. chapter meetings.

As we look into the future for our Industry we will find a continued effort upon the part of the inspired young foundrymen to ascertain what the fundamentals are which produce good castings. As this information develops it will, in turn, be presented through the American Foundrymen's Association to its membership.

Therefore, in the interest of the Malleable Iron Industry it is of paramount importance that the companies have their organization maintain their interest by reviewing and reading the A.F.A. *Transactions'* papers and discussions that were presented at the many conventions.

It is regrettable that the convention which was to be held in Detroit April 30-May 4, has been cancelled in order to preserve transportation and hotel facilities. Our Industry can, however, be assured the effective work of the A.F.A. will still continue in a manner most helpful to its membership. The Association has arranged to conduct a "Year Round Foundry Congress" in the course of which papers and discussions intended for presentation at the convention will be brought to the entire membership through the "American Foundryman."

Recommended Practices Alert for New Changes

By Chairman Wm. Romanoff, H. Kramer & Co., Chicago, Ill.

YEARS of work and planning by members of the various Non-Ferrous Recommended Practices Committees finally culminated in the publication by the A.F.A. of a book containing these recommended practices.

In my opinion, this book is a "must" for every engineer, metallurgist, foundry foreman, or foundry worker in the Non-Ferrous field. Its content is the consensus of the experiences of some of the best foundry personnel in the business.

During this war, when practically all castings require the pouring of test bars, new techniques will no doubt be developed for both test bars and castings. The committee should be alert for these changes, and they should be incorporated in the recommended practices.

While we have covered practically all of the standard alloys, either individually or in groups, it is our intention to write recommended practices for any other brass and bronze alloy that may come into popular usage. If you know of any alloys that cover wide, general usage and that the committee has overlooked, the chairman will be pleased to hear from you.

Fifty-Year Vets Honored By Manhattan Rubber Div.

IN recognition of rounding out 50 years of service with The Manhattan Rubber Mfg. Div., Raybestos-Manhattan, Inc., Andrew N. Van Riper and Morris G. Fitts were given gold pins studded with five diamonds, each diamond emblematic of five years of service beyond the 25-year mark. The presentation was made by Sumner Simpson, president, Raybestos-Manhattan, Inc.

WAR PRODUCTION CONFERENCE

At Chicago Holds Magnesium Panel

THE Third War Production Conference was held Thursday, March 29, at the Stevens Hotel, Chicago. The one-day conference was sponsored by various technical societies in cooperation with the WPB, Army and Navy. A registration of 3,000 brought together representatives of companies which had been the forefront of war production work to talk over current problems of production and manufacture.

The Chicago chapter, AFA, one of the sponsoring societies, organized three sessions or panel groups, before which nine papers were presented and discussed. The three panels, one being on precision castings and the other two on magnesium casting problems, covered subjects of prime importance to the foundry.

The luncheon meeting was addressed by Major General Levin H. Campbell, Chief of Ordnance, U. S. Army, who talked on "Building Firepower Through Technology." At the speakers' table the foundry industry was well represented by the presence of AFA Past President General Thomas S. Hammond, president, Whiting Corp.; AFA Past Director George W. Cannon, president, Campbell, Wyant & Cannon Foundry Co.; Harold S. Falk, president, Falk Corp.; and Thomas C. Drever, president, American Steel Foundries, AFA sustaining member.

The foundry panels were well attended with attendance averaging about 300 each. The program for these panels was as follows:

Panel No. 1

General Chairman—E. R. Young, Climax Molybdenum Co.

Chairman — J. P. Magos, Crane Co.

Papers—"Industrial Status of Precision Castings," by Capt. W. A. Morey, Chicago Ordnance District; "Equipment Trends in Precision Castings," by Capt. A. J. Dore, Chicago Ordnance District; "Gravity Head Investment Castings," by Howard F. Taylor, Naval Research Laboratory.

Panel No. 2

General Chairmen—E. R. Young, Climax Molybdenum Co., and Oscar Blohm, Hills McCanna Co.

Chairman — Wayne Martin, National Smelting Co.

Papers — "Comparison of Some American and European Cast Magnesium Alloys," by J. A. Davis, Battelle Memorial Institute; "The Properties and Characteristics of Commercial Magnesium Casting Alloys," C. E. Nelson, Dow Chemical Co.; "The Heat Treatment of 6% Aluminum — 3% Zinc Magnesium Alloys," by Dr. R. F. Thomas, Dodge Chicago Plant, Div. of Chrysler Corp.

Panel No. 3

Chairman—B. E. Sandell, Stewart Die Casting Div., Stewart Warner Corp..

Papers — "The Effect of Gas on the Properties of Magnesium Sand Casting Alloys," by R. S. Busk, Dow Chemical Co.; "The Reduction of Microporosity in Magnesium Alloy Castings," by J. C. DeHaven, Battelle Memorial Institute; "Grain Refinement of Magnesium Casting Alloys," by L. W. Eastwood, Battelle Memorial Institute.

French Foundrymen Look to the Future

IT IS apparent from a letter written by P. Chevenard, President of the Association Technique de Fonderie, Paris, France, which is reprinted below because of the interest it will hold for many American foundrymen, that when Paris capitulated to her enemies the spirit of her people was not shackled. The friendship between A.F.A. and the Association Technique de Fonderie has grown through the years.

"On the occasion of the recent liberation of the French territory, and particularly of our capital city, by the valiant troops of the Allied Armies, we are happy to write to you, in the name of all of the French foundrymen.

"We hope, as soon as possible, to resume our friendly relations which have been suspended for nearly five years, by reason of the occupation of our country by the Germans.

"With confidence, we express the wish that victorious peace, so long desired, may soon come, which will enable our two sister Associations to continue, as in the past, to work in close collaboration for the technical and scientific improvement of our industry.

"Moreover, by the resumption of the activity of the International Committee of the Technical Foundry associations, which we expect to be imminent, we also trust that the necessary measures may be determined as soon as possible of a common agreement among the associations of the different countries, to establish the calendar of the future international foundry congresses.

"As soon as the postal service will permit it, we shall be pleased to send you a copy of all of the publications that we have put out since the beginning of the year 1940, and we shall re-establish regular service to your address. We ask of you, in exchange, to kindly send us, as soon as you can, the publications put out by the American Foundrymen's Association during the same time."

Southern California Lecture Book Available

THE Southern California chapter this past year has carried on an extensive lecture course, and as a result of the course has prepared a very comprehensive book on the lectures given. Containing some 140 pages, the seven lectures given by various chapter members, together with a large number of pertinent illustrations, this book is the fruit of much labor. These lectures dealt with Design of Castings; Casting Processes (Static Casting, Centrifugal Castings, Die Casting); Selection of Cast Alloy; Cast Steel and Its Heat Treatment; Cast Iron and Its Heat Treatment; Cast Aluminum, Copper and Magnesium Alloys and Their Heat Treatment; and Inspection of Castings. The book was given to those finishing the course.

Anyone interested in obtaining a copy of the book should contact Henry E. Russill, secretary, Southern California chapter, c/o Eld Metal Co., Ltd., Los Angeles, Calif.

NEW ASSOCIATION MEMBERS

March 16 to April 15, 1945

• Twenty-five chapters have added 111 foundrymen to the New Members total. The Metropolitan Chapter annexed first place honors with 16 new faces; Chicago's 13 members took second position and Birmingham, which acquired 10 new men, finished third.

BIRMINGHAM CHAPTER

J. W. Allred, Shakeout Foreman, Jackson Industries, Inc., Birmingham.
Oliver Allred, Foundry Supt., Jackson Industries, Inc., Birmingham.
C. H. Boggs, Foreman, Production Foundries, Birmingham.
J. D. Bradley, Foreman, American Cast Iron Pipe Co., Birmingham.
Neil J. Lindsey, Core Room Foreman, Jackson Industries, Inc., Birmingham.
Milton E. Manuel, Production Foundry Supt., Jackson Industries, Inc., Birmingham.
I. V. Sigsbee, Maintenance Foreman, Jackson Industries, Inc., Birmingham.
Paul Stephens, Foundry Service, J. M. Tull Metal & Supply Co., Atlanta, Ga.
S. J. Summers, Casting Foreman, American Cast Iron Pipe Co., Birmingham.
C. H. Wood, Molding Foreman, Jackson Industries, Inc., Birmingham.

CANTON DISTRICT CHAPTER

Marshall D. Scott, Metallurgist, United Engineering & Foundry Co., Canton, Ohio.

CENTRAL NEW YORK CHAPTER

Robert B. Berguson, J. P. Ward Foundries, Inc., Blossburg, Pa.
Howard T. Kennedy, J. P. Ward Foundries, Inc., Blossburg, Pa.
John A. Kister, J. P. Ward Foundries, Inc., Blossburg, Pa.
John G. Kuster, J. P. Ward Foundries, Inc., Blossburg, Pa.
John Renwick, J. P. Ward Foundries, Inc., Blossburg, Pa.
***J. P. Ward Foundries, Inc., Blossburg, Pa. (Charles B. Ward, Pres.).**

CENTRAL OHIO CHAPTER

***Columbus Ohio Pattern & Mfg. Co., Columbus (A. E. Tietze, Sec.-Treas.).**
Edward G. Deibel, Foundry Foreman, Lattimer-Stevens Co., Columbus.
James T. Gow, Asst. Supv., Physical Metallurgy Div., Battelle Memorial Institute, Columbus.
***The Lattimer-Stevens Co., Columbus, Ohio (J. W. Fenneken, Supt.).**

CHESAPEAKE CHAPTER

James R. Power, Naval Research Laboratory, Washington, D. C.
Richard C. Wynne, Ensign, (U.S.N.R.), Naval Research Laboratory, Washington, D. C.

CHICAGO CHAPTER

LeRoy W. Anderson, Molder, Howard Foundry Co., Chicago.
Harry Apgar, Foreman, Wm. E. Pratt Mfg. Co., Joliet, Ill.
Fred W. Blaisdell, Jr., Mgr., Industrial Relations, Barco Mfg. Co., Chicago.
Richard C. Ferguson, Chief Met., The Western Foundry Co., Chicago.
E. W. Hennings, Foreman, Wm. E. Pratt Mfg. Co., Joliet, Ill.
Fred Johansen, Sivyer Steel Casting Co., Chicago.
Lee Loeb, President, Warren Sand Co., Chicago.
Welton A. Luecke, Co-Owner, Acme Pattern & Model Works, Chicago Heights, Ill.
William Moran, Foreman, Wm. E. Pratt Mfg. Co., Joliet, Ill.
Stanley W. Moulding, Sr., Mech. Prod. Engr., Indianapolis, Ind.
Barney J. Parzyck, Foreman, Wm. E. Pratt Mfg. Co., Joliet Ill.
Paul R. Pomrehn, Acme Pattern & Model Works, Chicago Heights, Ill.
Bruce J. Squires, Asst. Fdry. Supt., Alloy Casting Co., Champaign, Ill.

DETROIT CHAPTER

John Geisler, Chief Inspector, Lincoln Brass Works, Detroit.
Joseph A. Golochowicz, General Foreman, Lincoln Brass Works, Detroit.
***Lincoln Brass Works, Inc., Detroit (Joseph G. Wamser, Fdry. Supt.).**
William Sutliff, Foundry Foreman, Lincoln Brass Works, Detroit.

EASTERN CANADA & NEWFOUNDLAND CHAPTER

***Alloy Foundry, Inc., Merrickville, Ont. (James Leslie Clark).**
***Liberty Smelting Works, Montreal, Que. (D. Weissman, Gen. Mgr.).**
***United Smelters & Metals, Inc., Montreal, Que. (Moses Deitcher, Chemist).**
Charles Zubis, Molder, Canadian Car & Foundry Co., Ltd., Montreal, Que.

METROPOLITAN CHAPTER

Raymond Daly, Foundry Tech., Wright Aeronautical Corp., Paterson, N. J.
Edward A. Ellis, Chief Chemist, Barth Smelting & Refining Works, Inc., Newark, N. J.
Howard C. Frisbie, Mgr., Foundry Sales, E. F. Houghton & Co., Cheshire, Conn.
P. E. Gerhard, Mgr.-Sales, American Steel Castings Co., Newark, N. J.
James O. G. Gibbons, Vice-Pres., Gibbons Engineering Co., Inc., Newark, N. J.
***B. F. Hirsch, Inc., New York City (B. L. Levinson, Vice-Pres.).**
Francis A. Keough, Melting Leader, Sperry Gyroscope Co., Great Neck, L. I., N. Y.
Monroe Lichtenstein, Foundry Technician, Wright Aeronautical Corp., Paterson, N. J.
V. J. Nolan, Asst. Gen. Sales Mgr., National Carbon Co., Inc., New York City.
Fred C. Paffrath, Sales Repr., American Steel Castings Co., Newark N. J.
Chas. Rampolla, Sales Engr., American Steel Castings Co., Newark, N. J.
***Reynolds Research, Glen Cove, N. Y. (Dr. Lucio Mondolfo, Met.).**
Thos. V. Sollas, Sales, E. F. Houghton & Co., Paterson, N. J.
John C. Somers, Claude B. Schneible Co., Long Island City, N. Y.
Carl Szego, Prod. Mgr., Barth Smelting & Refining Works, Inc., Newark, N. J.
John L. Webster, Master Mechanic, Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.

MICHIANA CHAPTER

Noel A. Baker, Star Pattern & Mfg. Co., Benton Harbor, Mich.
George E. Garvey, Pattern Foreman, City Pattern Works, South Bend, Ind.
W. H. Stokoe, Service, International Molding Machine Co., Benton Harbor, Mich.

NORTHEASTERN OHIO CHAPTER

Roger D. Carver, Foundry Supt., Standard Stoker Co., Erie, Pa.
***Mohawk Aluminum Castings Co., Cleveland (Alfred H. Huck, Gen. Mgr.).**
A. Townhill, Mgr., Light Metals Div., Thompson Products, Inc., Cleveland.

NORTHERN CALIFORNIA CHAPTER

Tony Barrozo, Molder, Pacific Steel Casting Co., Berkeley, Calif.
Wm. F. Maguire, Abrasive Engr., San Francisco, Calif.

ONTARIO CHAPTER

C. S. Gilbert, Supt., Canada Iron Foundries, Ltd., St. Thomas, Ontario.
J. S. Hawken, Met. Engr., Electro Metallurgical Co., Welland, Ontario.
William E. Hodgson, Met. Engr., Canadian General Electric Co., Ltd., Toronto, Ont.
Ronald Tipping, Sales Engr., Otis Fensom Elevator Co., Ltd., Hamilton, Ont.
J. S. Ward, Turbo Research Ltd., Leaside, Ontario.

OREGON CHAPTER

A. L. Evans, Prop., West Side Pattern Works, Portland.
E. J. Hyche, Mgr., Rich Mfg. Co., Portland.
Eason G. Miller, Inspector, Oregon Brass Works, Portland.

PHILADELPHIA CHAPTER

Roy D. Haworth, Jr., Asst. Chief Engr., Lehigh Foundries, Easton, Pa.
Edwin F. Nunemacher, Jr., Chemist, Selas Corp. of America, Philadelphia.

QUAD-CITY CHAPTER

Jas. A. Robinson, Foundry Supt., Construction Machinery Co., Waterloo, Iowa.
W. G. Schuller, Asst. Purchasing Agent, Caterpillar Tractor Co., Peoria, Ill.

ROCHESTER CHAPTER

George S. Benedict, Hetzler Foundries, Inc., Rochester, N. Y.
Walter C. DeRoller, Patternmaker, The Symington-Gould Corp., Rochester, N. Y.
Raymond J. Harmon, Patternmaker, The Symington-Gould Corp., Rochester, N. Y.

SAGINAW VALLEY CHAPTER

William Ralph Butt, Purchasing Dept., Saginaw Malleable Iron, Saginaw, Mich.
Carlton D. Evans, Saginaw Malleable Iron, Saginaw, Mich.
Major Liu Kiang-Min, Saginaw, Mich.
Wm. Palen, General Foundry & Mfg. Co., Flint, Mich.
Bernard D. Reeder, Inspector, Saginaw Malleable Iron, Saginaw, Mich.

*Company Member.

ST. LOUIS DISTRICT CHAPTER

***Aeroloy Company, St. Louis, Mo. (B. J. McMullen, Gen. Mgr.).**
Albert S. Hard, Fdry. Supt., St. Louis Steel Casting Co., St. Louis, Mo.
John Mauterer, Supt., Aeroloy Co., St. Louis, Mo.
Charles F. Rohlkoetter, Gen. Foreman, C. S. & A. Dept., American Steel Foundries, E. St. Louis, Ill.
Fred C. Rohlkoetter, Shop Supt., American Steel Foundries, E. St. Louis, Ill.
Milton G. Rosenberg, Prod. Mgr., Aeroloy Co., St. Louis, Mo.

SOUTHERN CALIFORNIA CHAPTER

Andrew J. Conahan, Foundry Foreman, General Electric Co., Ontario, Calif.
H. J. Heath, Foundry Supt., Aluminum Co. of America, Los Angeles.
Lloyd B. Jensen, Partner, Patterncraft Co., Los Angeles.
***W. & W. Foundry Co., Gardena (Donald Walker, Pres.).**

TEXAS CHAPTER

Fred Mosley, Owner, Machinery Mfg. Co., Waco, Texas.
R. A. Stevenson, Head of Zinc Die Dept., Guiberson Corp., Dallas.

TOLEDO CHAPTER

***Associated Engineers, Inc., Fort Wayne, Ind. (Alan Richardson).**

TWIN-CITY CHAPTER

Norman S. Bjork, Industrial Engr., St. Paul Foundry & Mfg. Co., St. Paul, Minn.
Charles Britzius, Partner, Twin City Testing & Engrg. Lab., St. Paul, Minn.
***Continental Machines, Inc., Minneapolis, Minn. (Roy Hutchins, Expediter).**
William G. Kloster, Owner, Wm. G. Kloster Co., Minneapolis, Minn.
Lyle Soderholm, Foreman, Melting Dept., Minneapolis Electric Steel Castings Co., Minneapolis, Minn.
Roderick Syck, Vice-Pres., % Thomsen Foundries Corp., Duluth, Minn.

WESTERN MICHIGAN CHAPTER

***Cadillac Brass & Aluminum Foundry, Cadillac, Mich. (R. J. Dykema, Gen. Mgr.).**
Walter Carlson, Crane Operator, West Michigan Steel Foundry Co., Muskegon, Mich.
Richard D. Clark, Time Study Engr., Cadillac Malleable Iron Co., Cadillac, Mich.

WISCONSIN CHAPTER

Paul H. Carlson, Engr., Norton Co., Milwaukee.

OUTSIDE OF CHAPTER

Fred Cousans, Works Mgr., Catton & Co., Ltd., Leeds, Yorkshire, England.
R. S. Flynn, Chief Inspector, Fort Pitt Steel Casting Co., McKeesport, Pa.
***The Glacier Metal Co., Ltd., Alperton, Wembley, England (William H. Tait).**
Library, Polish Air Force, London, S.W. 2, England.
Eng. Manoel A. Morais, Instituto de Pesquisas Tecnologicas de S. Paulo, Sao Paulo, Brazil, South America.
Stephen Stanworth, Director, Thomas Ashworth & Co., Ltd., Burnley Lancs., England.

*Company Member.

A.F.A. Sends Regrets On 1945 Detroit Meeting

RECALLING that the 1945 Foundry Congress of A.F.A. was scheduled to have begun on April 30 in Detroit, the Executive Committee of the Board recently expressed to the Directors of the Detroit Chapter the Association's regrets for cancellation of the meeting. Meeting in Chicago at the Palmer House, April 26-27, the Committee directed that an appropriate letter be sent to the Chairman of the Chapter, R. G. McElwee, Vanadium Corp. of America, Detroit, reading in part as follows: *"We sincerely regret the circumstances that prevented holding the 49th Annual Meeting of A.F.A. in Detroit, commencing April 30, but we sincerely trust that the Detroit Chapter will renew its invitation to the Association at some future date when conditions permit."*

R. G. McElwee

As previously announced, the 1945 Annual Meeting of A.F.A. will be held in Chicago, July 18, at the time of the Annual Board Meeting, but only on a representative basis and with out-of-town attendance limited to 50 in accordance with O.D.T. restrictions on wartime meetings.

With 1946 marking the 50th Anniversary of the Association, it is hoped that wartime conditions may permit the holding of a Golden Jubilee Convention and Exhibit next year, but any announcement as to time and place must wait upon events.

L. B. Knight Returns to Industry From Navy

LESTER B. KNIGHT, formerly lieutenant commander in the U. S. Naval Reserve, has recently been honorably discharged.

Mr. Knight went into naval service in 1943 as an assistant in charge of foundry and forge problems, Bureau of Ships, Washington, D. C. During his tour of duty, he has had many tasks, including equipping and putting into production some 60 foundries and forge shops throughout the country. He also assisted in procuring many difficult castings for the Navy. Prior to leaving the service, Mr. Knight, with Adm. Fischer, made an extensive survey for Secretary of Navy Forrestal on foundry, pattern and forge shops in relation to the increasing of production and bettering working conditions.

Returning to civilian life, Mr. Knight intends to set up his own company in Chicago, as a consulting engineer on foundry management and operation problems.

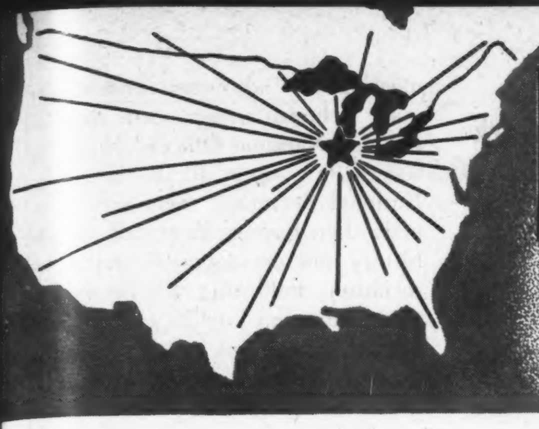
Chicago Ends Lecture Course at Northwestern

THE final meeting of the Chicago chapter's popular 1945 Foundry Lecture Course was held on April 11 at the Technological Institute of Northwestern University, Evanston, Ill.

Chairman Bruce L. Simpson, president, National Engineering Co., presented the speakers to the attending foundrymen and their guests. A. W. Gregg, executive engineer, Equipment Div., Whiting Corp., gave a brief history of the AFA, its part in the great advances made in the foundry, and outlined the extensive projects which the Association now has under way.

Dean O. W. Eshbach, of the Institute, spoke of the background and experiences of Walter P. Murphy, culminating in the gift which made the Technological Institute possible and the co-operative plan on which it is conducted.

The physical aspects of the Institute — its building, equipment and departments — were described by Dean Eshbach, after which the foundrymen and guests were conducted on a tour of the Institute by student members of Northwestern University.



CHAPTER ACTIVITIES News

See page 102 for list of Chapter representatives whose reports of local activities appear in this issue.

TEXAS CHAPTER GUESTS
Hold All Day Meeting at Lufkin

By Leroy G. Stenzel

TWO outstanding Texas foundries located at Lufkin, the Lufkin Foundry and Machine Co. and Texas Foundries, Inc., were hosts to members of the Texas chapter at an all day meeting April 12.

The morning was spent in visiting the two foundries where some noteworthy practices were seen. The plant visitation group was treated to a real tantalizing luncheon of southern fried chicken at the Lufkin Foundry and Machine Co., with W. C. Trout, president of the foundry, acting as host. The afternoon was spent at the Lufkin Country Club with the foundrymen pounding sand with mashies and attempting to impersonate the antics of Nelson, Snead, Sarazen, etc.

The technical session in the evening was highlighted by the presence of National Director I. R. Wagner, Electric Steel Castings Co., Indianapolis, Ind., and AFA Secretary Bob Kennedy. Mr. Wagner, chairman, AFA Board Committee on Chapter Contacts, and Mr. Kennedy spoke a few words. A short coffee talk was made by W. C. Trout on "Industrial Relations as Affecting the Post War Industry." Chapter Chairman F. M. Wittlinger, Texas Electric Steel Castings Corp., Houston, then introduced the main speaker, J. E. Gitzen, president, Delta Oil Products Co., Milwaukee, Wis. An interesting discussion of factors involved in the use of core binders was given. He stressed the necessity of complete baking of any oil sand cores.

Following the technical talk, the members were treated to an old-fashioned southern barbecue. Secretary Kennedy reported that the meal was beyond description and that those Northern members present have something to talk about to their friends. The meat was so tender it could be cut with a spoon, quoted Mr. Kennedy. The entertainment was such that could only be heard and seen in a southern town as Lufkin. About six colored residents had formed a string band and their songs and dances were thoroughly enjoyed by those present.

Jack Klein, Texas Foundries, Inc., was chairman, Program Committee.

BARLOW STRESSES SUPERVISION
For Good Cupola Operation

By J. Ralph Turner

STATING that the main consideration in cupola control is supervision and that the majority of cupolas in the country are operated by a "cupola tender" instead of a trained melter, T. E. Barlow, foundry engineer, Battelle Memorial Institute, Columbus, O., kept his audience interested in a most important subject. The members of the Western New York chapter were deeply engrossed at the April 13 meeting as the speaker continued to say that cupolas operated without supervision result in lack of economy and too often it is necessary to make

The Texas Chapter holds an outdoor meeting climaxed with a real southern barbecue and entertainment.

a much higher strength iron than is specified to be sure of meeting specifications. Many times expensive alloys are used in order to get the necessary strength from a poor base iron, whereas close control would produce the proper iron from the cupola. In a discussion on coke bed, the speaker said though the coke bed may be perfect at the start of the heat, this is quickly changed due to burnout during operation, and compensation should be made to retain the proper height of the bed. This can be regulated better by using a volume measurement on the bed and also on the coke splits. Due to difference in weight of coke, a more consistent height of bed and uniform temperature can be maintained by measuring the coke splits by volume instead of by weight. A definite time schedule in burning the coke bed should be used in addition to accurate measurement of the height, suggested the lecturer.

Big Quad City Crowd Hears Levi's Cupola Talk

By H. L. Creps

THE season's largest meeting of the Quad City chapter was held March 19 at the Fort Armstrong Hotel, Rock Island, Ill. One hundred and twenty-one members and guests assembled at the meeting, which was presided over by Chairman R. E. Wilke, Deere and Co., Moline, Ill. Technical chairman H. Bornstein, Deere and Co., introduced Wally Levi, metallurgist, Lynchburg Foundry Co., Lynchburg, Va. His topic for the evening was "Cupola Operation and Control."

Mr. Levi gave a comprehensive review of melting practice in two foundries operated by his company. Importance of maintaining uniformity through close supervision of raw materials was an impressive feature of his talk. A description was made of the methods used for the use of scavenging and deoxidizing elements as late additions to ladles. An unusual practice for carbon control involving use of three kinds of coke aroused much interest. A clear view of advantages obtained by the balanced blast and moisture control systems as applied to better cupola control was explained by the lecturer.

Canton Celebrates First Year of Chapter Work

By George M. Biggert

WITH over 80 present, the Canton chapter on the evening of April 20 celebrated their first anniversary at the Elks Club in Canton. Following the dinner meeting, Chapter Chairman Karl Schmidt, United Engineering and Foundry Co., Canton, introduced a number of guests who were present. He called special attention to Pat Dwyer, "The Foundry," and Pat, in his inimitable fashion, gave an entertaining and serious discussion of certain phases of international relations, with reminiscences of the foundry industry.

Chairman Schmidt then requested George Biggert, chapter secretary, who had been designated as Chairman, Committee on Tellers, to report on the election of officers. Mr. Biggert in his report announced that H. G. Robertson, American Steel Foundries, Alliance, Ohio, had been elected Chairman. Other officers elected were: I. M. Emery, Massillon Steel Casting Co., Massillon, Ohio, as Vice-Chairman from the Central Area; C. F. Bunting, Pitcairn Co., Barberton, Ohio, as Vice-Chairman from the West Area; C. E. Shaw, American Steel Foundries, Alliance, Ohio, as Secretary; Otis D. Clay, Tuscora Foundry Sand Co., Canal Fulton, Ohio, was reelected as Treasurer, and Karl Schmidt was elected to the Executive Committee as Past Chairman. Three directors were elected from three areas, central, west, and east, those three being elected for the West Area were Chas. W. McLaughlin, Barberton Foundry Co., Barberton, Ohio; Chas. Reyman, Jr., Atlantic Foundries, Akron, Ohio; and Charles Scoville, Babcock & Wilcox Co., Barberton, Ohio. Those being elected from the Central Area were Earl Brown, Union Metal Mfg. Co., Canton, Ohio; H. E. McKimmey, Carnegie Illinois Corp., Canton, Ohio; and C. B. Williams, Massillon Steel Casting Co., Massillon, Ohio. Men elected for the East Area were F. K. Donaldson, Machined Steel Castings Co., Alliance, Ohio; Lewis Way, Columbiana Foundry Co., Columbiana, Ohio; and Fred C. Glass, The Deming Co., Salem, Ohio.

Following the announcement of the election of officers, the business meeting was adjourned and Chairman Schmidt announced that as this was National Officers' Night, he was calling upon R. E. Kennedy, National Secretary. Secretary Kennedy then gave a short talk on the history and development of the Association. Following this, he showed some slides on earlier casting production going back to prehistoric ages. Following Secretary Kennedy, Frank Dost, A.F.A. national director, Sterling Foundry Co., Wellington, Ohio, gave a very friendly greeting from the neighboring chapter, Northeastern Ohio. He then discussed certain postwar problems confronting the foundry industry, emphasizing the need for technical development and control. Chairman Schmidt introduced National Director W. B. Wallis, president, Pittsburgh Lectromelt Furnace Corp., Pittsburgh, Pa. Mr. Wallis discussed certain problems which had confronted the Board of Directors this past year. He especially called attention to the emergency program which had been necessitated by the cancellation of the 1945 Convention. He further discussed the change in dues structure for sustaining and company members.

Tentative Program for Montreal Regional Meet

By R. E. Cameron

WORKING diligently and profoundly the Eastern Canada and Newfoundland chapter is climaxing its year of activity with a two-day regional conference. The meeting is scheduled for Thursday, May 17, and Friday, May 18. Headquarters will be the Mount Royal Hotel, Montreal. Thursday has been set aside for plant visitations as nine companies and one trade school in Montreal open their doors for inspection. The evening session will be highlighted with an address by F. G. Sefing, International Nickel Co., on "Molding Methods for Sound Castings."

Friday morning is set aside for plant visitation but in the afternoon the technical meetings will begin. Three sessions are listed: gates and risers, sand and melting practice. The two-day affair will be topped off with a stag dinner Friday evening.

Schedule of May Chapter Meetings

May 3
Saginaw Valley
Fischer Hotel, Frankenmuth, Mich.
J. H. Smith
Saginaw Malleable Iron Div.,
General Motors Corp.
"Progress With Better Methods and Motion Study"

May 4
Western New York
Hotel Touraine, Buffalo
Fred Chambers
National Gypsum Co.
"Gypsum Cement Pattern Making"

May 7
Metropolitan
Essex House, Newark, N. J.
Clarence Cline
Cooper Alloy Foundry Co.
"The Development and Application of Pattern Equipment for the Production of a Light Alloy Casting"

Central Indiana
Athenaeum, Indianapolis
Ralph Lee
Grede Foundries, Inc.
"Foundry Cost Systems"

Chicago
Chicago Bar Association
Round Table Meeting
Steel—*"Foundry Maintenance"*
Gray Iron—*"Modern Molding Methods"*
Non-Ferrous—*"Magnesium Foundry Control"*
Malleable—*"The Advantages of Mechanization in the Foundry"*

May 8
Northern Illinois-Southern Wisconsin
Faust Hotel, Rockford
Old Timers Night

May 10
Northeastern Ohio
Cleveland Club
Old Timers Night

Texas
Lufkin

St. Louis
DeSoto Hotel
H. Bornstein
Deere & Co.

May 11
Rochester
Seneca Hotel

Philadelphia
Engineers' Club
Dr. J. T. MacKenzie
American Cast Iron Pipe Co.
"Centrifugal Casting"

Ontario
Royal York Hotel, Toronto
Annual Meeting and Entertainment

Northern California
Engineers' Club, San Francisco
"Casting Design"

Central New York
Hotel Onondaga, Syracuse
F. J. Sefing
International Nickel Co.
"A Study of Molding Methods for Sound Castings"

May 14
Western Michigan
Ferry Hotel, Grand Haven, Mich.
J. A. Gitzen
Delta Oil Products Co.
"Chemical and Physical Properties of the Various Organic and Inorganic Binders Used in Molds and Cores"

Cincinnati
Engineering Society Headquarters
E. H. Schleede
U. S. Gypsum Co.
"Patterns of Gypsum Cement and Metal Casting in Plaster"

May 17
Detroit
Rackham Memorial
Round Table Meeting
Gray Iron, Brass and Malleable

May 17-18
Eastern Canada and New Foundland
Mount Royal Hotel, Montreal
Regional Conference

May 18
Birmingham
Tutwiler Hotel
J. F. Klement
Ampco Metal, Inc.
"Melting Mediums for Bronze Alloys"

Southern California
Clark Hotel, Los Angeles
Adrian Den Breejen
Hydro-Blast Corp.
"Foundry Sands"

May 21
Quad City
Hotel Fort Armstrong, Rock Island, Ill.
G. W. Torrence
Caterpillar Tractor Co.
"Industrial Relations"

Erie, Pa.
Moose Club
J. H. Smith
Saginaw Malleable Iron Div.,
General Motors Corp.
"Progress With Better Methods and Motion Study"

May 23
Twin City
Curtis Hotel, Minneapolis
A. F. Cota
A. O. Smith Corp.
"Industrial Radiography"

May 24
Portland
Heathman Hotel
Adrian Den Breejen
Hydro-Blast Corp.
"Foundry Sands"

May 26
Chesapeake
Belvedere Hotel
Annual May Party

May 28
Central Ohio
Fort Hayes Hotel, Columbus
C. E. Bales
Ironton Fire Brick Co.
"New Developments in Foundry Refractories"

JUNE MEETINGS

June 16
Quad City Chapter
Camp Nobel, Moline, Ill.
Annual Picnic

BASIC COST SYSTEM
Urged for Non-Ferrous Castings

By Herbert F. Scobie

THE Twin City chapter met at the Curtis Hotel, March 28, for the seventh regular meeting of the season. One hundred-twenty members and guests heard W. B. George, chief metallurgist and foundry engineer, Lavin and Sons, Inc., Chicago, in an authoritative discussion of "Brass and Bronze Castings."

A motion picture showing the operation of speedslingers and sandslingers was arranged by the Foundry Supply Co., St. Paul. H. G. Schlichter, sales manager, Beardsley and Piper Co., discussed the film and answered questions.

Mr. George began his talk with a discussion of costs. Stating that the same casting is being made in a number of foundries with the price ranging from 28 cents a pound to almost twice as much, he emphasized the lack of valid cost information among foundry operators, a situation general throughout the industry. Know your costs, or fail—profits of the present era will not exist in the post-war period, warned the speaker.

The practice of bidding low merely to get the job without regard for cost has led many large manufacturers to let out non-ferrous castings to smaller foundries, because they can purchase castings cheaper than they can make them. The old bit of philosophy, "Let the buyer beware," is reversed for the foundryman to "Beware the chiseling buyer." Foundries have been forced out of business as a result of this practice of real low bidding.

So that an order will be placed with a foundry deserving it, i.e., one that can make the castings for a reasonable cost at a reasonable profit, Mr. George recommended a basic cost system. The system was explained briefly and illustrated by three examples of non-ferrous castings. Overhead, which is to include material costs (except metal), was placed at 150 per cent of labor costs, because on any job someone is going to bid on the basis of that figure. Hazard, a new cost factor that caused much debate, was a percentage of combined labor and overhead based on scrap possibilities, test bar requirements, loss of first few castings, and special tests to be met. In the examples, hazard ran from 5 per cent on bushings and bar stock to 200 per cent on an 800-pound injector body which had to pass a pressure tightness test. Metal cost included a 10 per cent allowance for loss due to several remeltings. A twenty per cent profit was allowed. Contrary to common practice but in accord with desirable sales technique, the speaker advised selling castings by the piece instead of by the pound.

An excellent description of shrinkage phenomena led to a discussion of pouring temperatures, risering and directional solidification. Blind risers were recommended for many applications, but it is not necessary to use a core to admit atmosphere as is customary in steel foundries. Shape and section size influence the amount of contraction to an important degree as shown by tubular castings which shrink more along the cylinder axis than across the diameter. Mr. George recalled a casting in which this was not taken into account, and, as a result, the bore would not clean up in machining.

Cement bonded 70-mesh sand or a completely dried mold were suggested for heavy castings. To vent chills, drill three-quarter inch holes, pack with core sand, and bake. Direct contact with the metal is avoided by wiping the face of the chill with core oil and sprinkling with sand before baking.

National Officers Night At Central New York

By John A. Feola

AN outstanding program devoted to "Chemistry of Cupola Operation" was presented by W. A. Pennington, metallurgist, Carrier Corp., Syracuse, N. Y., before the Central New York chapter. At this April meeting the speaker explained various chemical formulas and presented numerous slides showing how air volume and coke ratio affect cupola operation and casting losses.

Prior to the main talk, Chapter Chairman L. E. Hall, Syracuse Chilled Plow Co., introduced N. F. Hindle, director, Technical Development Program. Mr. Hindle explained the work of the Technical Development Committee in relation to sand testing, cupola research, apprentice training and other activities.

The Central Aircraft Council met at the Pangborn Corp., Hagerstown, Md., March 8 and 9 to study and discuss numerous problems pertaining to aircraft metals. Members of this council include many engineering and production executives from various aircraft companies and divisions throughout the country.

Left—Anthony Cristello addressing the Saginaw Valley chapter. Center—Bob Dominic (left) waits patiently as Bernard Stuecker dives into the chicken platter. Both men are from Buick's aluminum foundry. Right—B. F. Wiand tells the foundrymen there are "rat tales" in FBI work, too.

Birmingham Holds Two Sessions During March

By J. P. McClendon

BIRMINGHAM chapter enjoyed a twin bill in March with dinner meetings and technical sessions on March 2 and 23.

The speaker for the March 2 meeting, with 86 members present, was H. H. Judson, foundry superintendent, Gould Pumps, Inc., Seneca Falls, N. Y., who gave a very interesting talk on "the elimination of risers in pouring heavy gray iron pressure castings." This is done by melting an iron of white iron composition in one cupola and another of gray iron composition in another. The white iron is tapped into a ladle and then inoculated with the gray iron, resulting in a low carbon-medium silicon gray iron. This inoculated iron must be poured within ten minutes after inoculation to secure the full benefits of the process. It is poured into very hard-rammed molds.

When it is found necessary to use risers, they are placed in a position which will not subsequently be a machined pressure-bearing surface.

The speaker emphasized that his company is able to meet the severest pressure test requirements without the use of alloys by their white iron inoculation process.

On March 23, Adrian C. Den Breejen was the speaker of the evening and his subject, "Sand Recovery from Hydraulic Cleaning," was well received. The advantages of sand reclamation in material obtained and money saved was clearly outlined. Using colored slides to illustrate his lecture, Mr. Den Breejen showed groups of sand grains, new and reclaimed, explaining that the shape and size of the grains are determined largely by the degree and kind of movement to which they have been subjected by the force of nature.

The lecturer pointed out that in some cases reclaimed sand was better than new sand because organic matter and other impurities in new sand are removed in the reclaiming process. "The sand is strengthened by the removal of the weaker grains which could not stand up to the test of the reclamation process," he said.

Non-Ferrous Plus FBI Interest Saginaw Men

By Joseph J. Clark

THE many factors that must be considered in melting, pouring, gating, molding and core practice were presented by Anthony Cristello, Eclipse Pioneer Div., Bendix Aviation, at a technical session held by the Saginaw Valley group April 5. The speaker pointed out that in the past many castings were produced which had smooth finish and good general appearance, but which would nowadays be considered scrap due to internal defects, cracks and other causes. The rigid requirements of the aircraft industry and

The Saginaw Valley group has a good turnout for dinner as indicated in this photograph.

Enjoying their steak (?) at the April meeting of the Northern California chapter are (left to right): George White, Enterprise Engine & Foundry Co.; L. M. Osborne, Produc-trol Pacific Co.; Charles Hoehn, Jr., Enterprise Engine & Foundry Co.; L. D. Pridmore, International Molding Machine Co.; and Chapter President Ralph C. Nash, San Francisco Iron Foundry.

the good work of the light metals foundrymen in meeting these requirements have had a profound beneficial effect on the foundry in general.

A brief, interesting talk delivered by B. F. Wiand, Detroit FBI office, on "Wartime Activities of the FBI" was enjoyed by the two hundred members present.

Giele Presents Materials Handling at Philadelphia

By B. A. Miller

ACQUAINTING themselves with the various types of handling equipment in the foundry, the Philadelphia chapter members were treated to a rare and instructive foundry lecture. Walter S. Giele, Walter Giele Co., Lebanon, Pa., was the speaker at this meeting and demonstrated, through the use of slides, the various types of foundry equipment.

Harry Titgen, sales engr., Quaker City Foundry, acted as Technical Chairman for the April meeting.

Crane Junior Fundrymen Elect New Officers

By Chester Celenga

THE Crane Technical High School, Chicago, Ill., Junior Foundrymen of America, have elected new officers as the school year draws to a close. The newly elected officers are: Richard Underwood, President; Chester Celenga, Secretary-Treasurer, and Sam Bratta, Sergeant-at-Arms.

Coastal Foundrymen Hear Pridmore on Core Blowing

By Richard Vosbrink

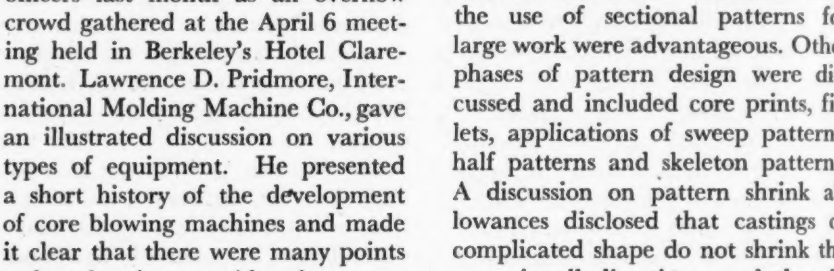
THE interest shown in modern foundry practice was more than gratifying to Northern California officers last month as an overflow crowd gathered at the April 6 meeting held in Berkeley's Hotel Claremont. Lawrence D. Pridmore, International Molding Machine Co., gave an illustrated discussion on various types of equipment. He presented a short history of the development of core blowing machines and made it clear that there were many points to be taken into consideration to get best results.

A coffee talk by George White, supervisor of foundry production, Enterprise Engine and Foundry Co., South San Francisco, explained the use of the Produc-trol System, to an interested audience. Tom Osborne, manager, Produc-trol Pacific Co., added some important information by answering various questions.

Manwell Points Out Pattern Design Faults

By William G. Gude

EMPHASIZING the adoption of split patterns whenever possible in the interest of larger production and lower cost, William C. Manwell, superintendent, Fulton Foundry and Machine Co., kept his audience intensely interested as he addressed the Northeastern Ohio chapter April 12. The speaker used slides to illustrate examples of split and solid patterns and went on to cite instances where the use of sectional patterns for large work were advantageous. Other phases of pattern design were discussed and included core prints, fillets, applications of sweep patterns, half patterns and skeleton patterns. A discussion on pattern shrink allowances disclosed that castings of complicated shape do not shrink the same in all directions, and that in the case of cored cylindrical castings



The Cleveland Trade School's open house was enjoyed by all members of the Northeastern Ohio chapter who could attend. Three chapter members are looking over a job completed by student Harold Young. These men are (left to right) Ben Fuller, A.F.A. Past President; Harold Young, student; W. C. Manwell, superintendent, The Fulton Foundry & Machine Co.; and A. C. Denison, The Fulton Foundry & Machine Co.

the principal shrinkage to be taken into account is along the length of the work. The core prevents shrinkage of the diameter.

The list of men nominated to serve as officers and directors of the Northeastern Ohio chapter were made as follows: chairman, A. C. Denison, Fulton Foundry and Machine Co., Inc.; vice chairman, Henry J. Trenkamp, Ohio Foundry Co.; secretary, Gilbert J. Nock, Nock Fire Brick Co.; treasurer, F. Ray Fleig, Smith Facing and Supply Co. The directors asked to serve for three years are: Leon Miller, Osborn Mfg. Co.; Dave Clark, Forest City Foundries Co.; Tom West, West Steel Castings Co.; Ed Metzger, Wellman Bronze and Aluminum Co.; Frank Cech, Cleveland Trade School. Paul Wheeler, Link Belt Co., was nominated for two years.

(Photo courtesy John Bing, A. P. Green Fire Brick Co.)

The Pattern Group Committee, Wisconsin Chapter, have been doing fine work throughout the year in presenting good programs at conferences and chapter meetings. The men of this committee are pictured above and, reading from left to right, are: A. M. Fischer, Chas. Jurack Co.; W. T. Schmidt, Gidding & Lewis Machine Tool Co., Fond du Lac; M. C. Frankard, Delta Mfg. Co.; A. G. Knudsen, committee secretary, Allis-Chalmers, West Allis; A. F. Pfeiffer, committee chairman, Allis-Chalmers, West Allis; H. J. Wade, Fairbanks Morse Co., Beloit; P. E. Riedel, Production Pattern Works; R. G. Metzger, Norberg Mfg. Co.; and A. Weberg, Belle City Malleable, Racine.

Wisconsin Pattern Group Displays Proud Record

A REMARKABLE record has has been set this past year by the Wisconsin chapter's Pattern Committee. Under the chairmanship of A. F. Pfeiffer, asst. gen. supt., Allis-Chalmers Mfg. Co., Milwaukee, Wis., this committee has sponsored several group discussions, but their program for the two-day Wisconsin Regional Conference on February 8 and 9 was their outstanding achievement. Among the sessions held by this committee at the Regional Conference were: "Problems in Purchasing Patterns and Apprentice Problems Affecting Pattern Shops"; "Core Blowing Demonstration" and a joint non-ferrous and gray iron meeting with "General Pattern Equipment on Up-To-Date Developments in Design and Casting Problems" being discussed.

This pattern committee has shown that the pattern groups of any chapter can obtain worthwhile results if they get together. The Association is trying to encourage all chapters to form similar pattern groups, as it is felt that cooperation between the pattern shop and foundry should be stressed to the utmost. The greatest credit for this development goes to Mr. Pfeiffer and members of his committee which are shown in the adjacent photograph.

Pausing between bites to talk shop are (left) Walter F. Norton, Anstice Co., president, Rochester chapter, and Leonard F. Tucker, City Pattern Works, South Bend, Ind., who was the chapter's principal speaker at their April meeting.

Foundry Woes Aired at Detroit Round Table

By H. H. Wilder

A THREE PRONGED spearhead was thrust into Detroit area foundry problems April 18 by authors of papers on foundry facings, testing methods and magnesium properties. The Rackham Educational Memorial Building was the theatre of operations.

Dr. John A. Ridderhof, F. B. Stevens, Inc., spoke to one group on the subject "Proper Applications of Facings." E. C. Hoenicke, Eaton Mfg. Co., acted as discussion leader following the speakers' coverage of recommended applications of seacoal, core washes, compounds and facing materials.

Industrial x-ray techniques, magnetic testing and related methods of steel casting testing were incorporated in a talk given by Don M. McCutcheon, Ford Motor Co. G. Vennerholm, Ford Motor Co., led the steel men into numerous questions concerning this paper on "Methods of Testing and Inspection."

The non-ferrous section heard W. C. Newhams, Dow Chemical Co., Midland, Mich., present his paper "Effect of Gas on Properties of Magnesium Sand Casting Alloys." This paper, prepared for the 1945 convention, was well received and discussed, with Leslie Brown, Magnesium Fabricators, Inc., Adrian, Mich., acting as leader.

(Chapter Activities continued on page 90)

Abstracts

NOTE: The following references to articles dealing with the many phases of the foundry industry, have been prepared by the staff of *American Foundryman*, from current technical and trade publications.

When copies of the complete articles are desired, photostat copies may be obtained from the Engineering Societies Library, 29 W. 39th St., New York, N. Y.

Aluminum-Base Alloys

DEGASSING. *(See Light Metals.)*

Casting Methods

LOST WAX. *(See Precision Casting.)*

Casting Methods

PRECISION METHODS. *(See Precision Casting.)*

Degassing

LIGHT METALS. *(See Light Metals.)*

Enameling

TITANIUM STEEL. *(See Steel.)*

Gray Cast Iron

METHODS. *"The Production of Builders' Castings,"* Charles Gillespie, FOUNDRY TRADE JOURNAL, January 25, 1945, vol. 75, no. 1484, pp. 65-68.

A description of pattern equipment, sand, and molding equipment used in the production of castings for building construction.

Gray Cast Iron

MOLDING PRACTICE. *(See Molding Practice.)*

Hardenability

TESTS. *(See Testing.)*

Inspection

FLUOROSCOPIC. *(See Radiography.)*

Inspection

GAMMA-RAY. *(See Radiography.)*

Light Metals

DEGASSING. *"Degassing Light Metals,"* W. Esmarch, T. Rommel, and K. Benther, METAL INDUSTRY, February 2, 1945, vol. 66, no. 5, p. 68.

Passing ultrasonic waves through a metal bath causes gas bubbles to form, and hence may be used as a means of degassing metal. However, in order for the process to be commercially successful, it seems that the waves will have to be generated within the metal bath. The authors discuss the commercial possibilities of melting in a high frequency furnace and generating supersonic waves within the metal by means of superimposing a steady magnetic field on the high frequency field of the furnace.

Magnesium-Base Alloys

DEGASSING. *(See Light Metals.)*

Magnesium-Base Alloys

MECHANIZED FOUNDRIES. *(See Mechanical Handling.)*

Materials Handling

MECHANICAL. *"The Principles of Mechanical Handling,"* J. V. Smith, FOUNDRY TRADE JOURNAL, January 18, 1945, vol. 75, no. 1483, pp. 45-48.

The author discusses some of the principles of materials handling which will enable the manufacturer to determine his need for mechanical handling systems and the type of equipment which would be most suitable.

Mechanical Handling

MAGNESIUM FOUNDRY. *"Mechanisation in a Magnesium Sand Foundry,"* MECHANICAL HANDLING, January, 1945, vol. 32, no. 1, pp. 2-10; February, 1945, vol. 32, no. 2, pp. 60-66.

A description of a modern British magnesium foundry which is completely mechanized. In combination with the mechanical equipment, an efficient ventilation system has permitted a high standard of working conditions to be achieved. Not only was the most modern equipment utilized, but much of the equipment was specially designed for this particular foundry. The design and layout of the foundry was greatly influenced by the imminent necessity of employing women for nearly all of the jobs in the foundry.

Metallography

SPECIMEN PREPARATION. *"Electropolishing of Microspecimens,"* Ulric J. Hochschild, METALS AND ALLOYS, February, 1945, vol. 21, no. 2, pp. 409-412.

A description of the technique of electropolishing and a new method of mounting small specimens.

Molding

SWEEP. *"Work on the Spindle,"* H. J. H. List, IRON AND STEEL, February, 1945, vol. 18, no. 2, pp. 51-52.

A description of molding by means of sweeps, in order to eliminate the making of a costly pattern for the production of just one or two castings. This process may be particularly useful when it is necessary to replace a part of a machine which is no longer in production.

Molding Practice

IRON. *"Methods and Problems Indigenous to a General Engineering Iron-Foundry,"* William Montgomery and John Doig, Jr., FOUNDRY TRADE JOURNAL, January 11, 1945, vol. 75, no. 1482, pp. 25-29, 33; January 18, 1945, vol. 75, no. 1483, pp. 49-53; January 25, 1945, vol. 75, no. 1484, pp. 71-74.

A description of molding methods in use in jobing foundries which produce only a limited number of castings with a minimum amount of pattern equipment.

Nickel-Base Alloys

PROPERTIES. *"Some Engineering Properties of Nickel and High-Nickel Alloys,"* B. B. Betty and W. A. Mudge, MECHANICAL ENGINEERING, February, 1945, vol. 67, no. 2, pp. 123-129.

An outline of the engineering properties of a number of alloys containing over fifty per cent nickel, followed by a list of references giving additional information on methods of fabricating nickel alloys.

Non-Ferrous Alloys

FOUNDRY PRACTICE. *"Producing Non-Ferrous Castings,"* R. MacLuckie, CANADIAN METALS AND METALLURGICAL INDUSTRIES, February, 1945, vol. 8, no. 2, pp. 28-31.

Some general observations on nonferrous foundry practice and special characteristics of 85-5-5-5, yellow brasses, manganese bronze, aluminum bronze, tin bronzes, and high lead tin bronzes.

Patternmaking

METHODS. *"Patternmaking,"* W. C. Perry, FOUNDRY TRADE JOURNAL, February 1, 1945, vol. 75, no. 1485, pp. 85-90.

A discussion of methods of making identical patterns to produce interchangeable castings.

Precision Casting

DEVELOPMENT. *"Precision Casting by the Lost Wax Process,"* Adam Dunlop, FOUNDRY TRADE JOURNAL, February 8, 1945, vol. 75, no. 1486, pp. 107-116, 118.

The author traces the development of precision casting by means of expendable patterns, starting with the early use of the lost wax process before the Christian era and discussing the Lentz system of lost wax casting, the application to dental casting, and the application to jewelry casting. He concludes his article with a detailed discussion of silicon esters which serve as a highly refractory binding material for precision casting.

(Abstracts continued to page 104)

Radiography . . .

investigator . . . helper . . . business-builder for the foundries of America

GROWING like Jack's beanstalk in its importance to American foundries, industrial x-ray has opened new possibilities for increasing quality and lowering costs for war and peacetime production.

Radiography has effected vast economies in materials, man-power, and machine time by eliminating defective parts before costly machining. A typical example:

Of 1500 simple aluminum housings—radiography found 18% unacceptable. Disastrous to the foundry? No! Radiography suggested better ways of casting. Rejections on many future deliveries dropped to less than 1%.

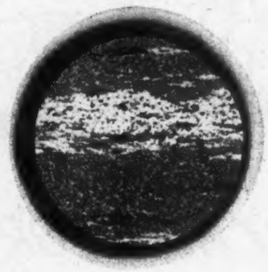
Or again, the case of a foundry which tried a very complex casting job which other foundrymen called "impossible":

A motor maker designed a new type lightweight crankcase with many desirable features . . . shrinkage at ports seemed insurmountable. X-raying successive castings led to successful technic . . . greatly enhancing the foundry's reputation.

Time after time—radiography, by showing what was wrong, has helped foundrymen make better castings . . . meet increasingly difficult requirements . . . build goodwill with foundrymen's customers throughout the world. For further information write Eastman Kodak Company, X-ray Division, Rochester 4, N. Y.

In addition to Radiography other photographic methods offer many advantages in the foundry.

Engineers, metallurgists, and production men are finding specialized photographic methods a great help in meeting today's requirements for rapid change-overs, redesigns, and modifications—speeding and increasing production, improving quality, and reducing costs . . . important now—more so in the days ahead.



MICRORADIOGRAPHY gives Valuable Data on Below-Surface Microstructure: Three-dimensional in effect. Reveals true shape of inclusions, and concentration change or distribution of elements, not otherwise visible.

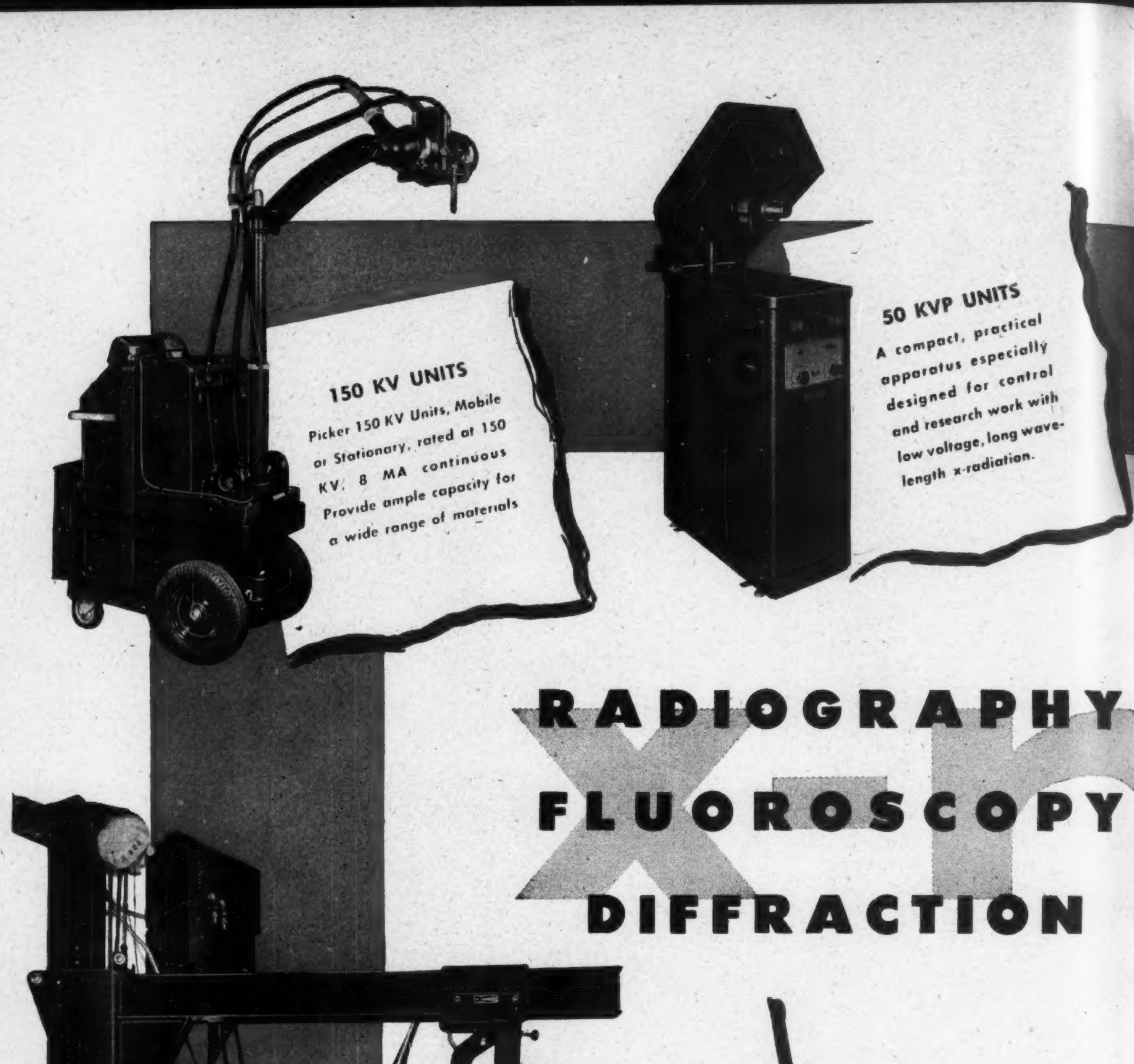
SPECTROSCOPY for Quantitative and Qualitative Analysis: Makes possible testing of melt before pouring. Fast analysis improves quality . . . increases production by decreasing waiting time.

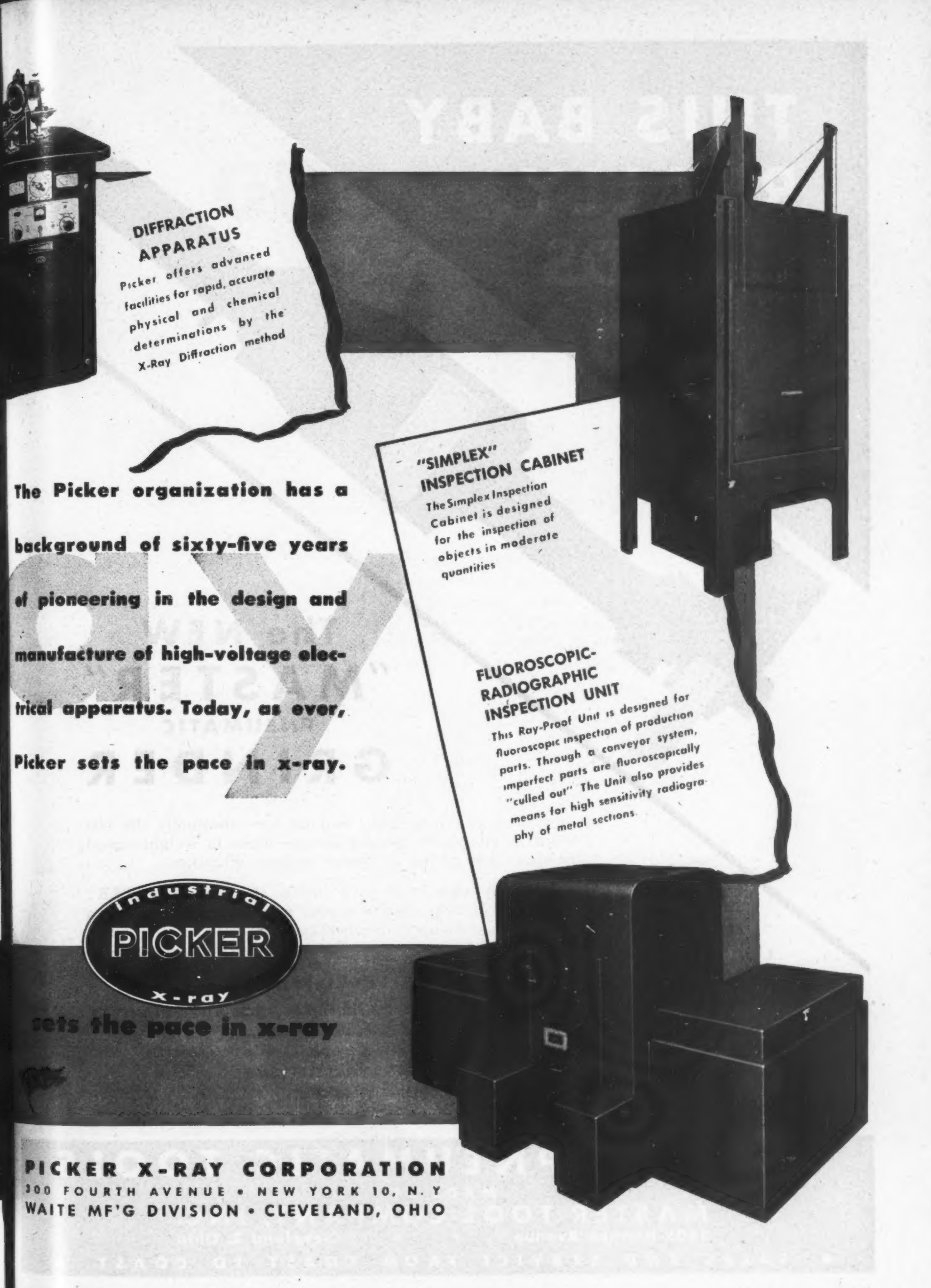
PHOTOMICROGRAPHY Investigates, Records, and Guides: A basic tool for microstructure examination. Helps set standards and check operations of processes involving changes in structure of material.

FUNCTIONAL PHOTOGRAPHY

Analyzes . . . Improves . . . Records . . . Reproduces


Kodak


150 KV UNITS
Picker 150 KV Units, Mobile or Stationary, rated at 150 KV, 8 MA continuous. Provide ample capacity for a wide range of materials
50 KVP UNITS
A compact, practical apparatus especially designed for control and research work with low voltage, long wavelength x-radiation.
RADIOGRAPHY
FLUOROSCOPY
DIFFRACTION
250 KV UNITS
Rated 250 KV at 15 MA, these units provide usable output range from 30 KV to 250 KV. Self contained transformer tubehead supplied on Stationary, Mobile, or Dolly Mounts for heavy duty radiography


DIFFRACTION APPARATUS
Picker offers advanced facilities for rapid, accurate physical and chemical determinations by the X-Ray Diffraction method
"SIMPLEX" INSPECTION CABINET
The Simplex Inspection Cabinet is designed for the inspection of objects in moderate quantities
The Picker organization has a background of sixty-five years of pioneering in the design and manufacture of high-voltage electrical apparatus. Today, as ever, Picker sets the pace in x-ray.
FLUOROSCOPIC-RADIOGRAPHIC INSPECTION UNIT
This Ray-Proof Unit is designed for fluoroscopic inspection of production parts. Through a conveyor system, imperfect parts are fluoroscopically "culled out" The Unit also provides means for high sensitivity radiography of metal sections.
Industrial
PICKER
x-ray
sets the pace in x-ray
PICKER X-RAY CORPORATION
300 FOURTH AVENUE • NEW YORK 10, N. Y
WAITE MF'G DIVISION • CLEVELAND, OHIO

CHAPTER ACTIVITIES

(Continued from Page 81)

Rose Presents Gray Iron Plans at Cincinnati

By J. Schumacher

AN interesting lecture on "The Gray Iron Foundry — Present and Future" was presented to the Cincinnati chapter at their April 9 meeting by W. W. Rose, executive vice-president, Gray Iron Founders Society, Washington, D. C. His discussion brought out the cooperation between the Gray Iron Founders Society and AFA and pointed out their fields do not overlap. The extensive use of gray iron throughout the country was described along with the functions of the Gray Iron Founders Society in relation to war agencies.

Den Breejen's Sand Talk Well Received at Beloit

By Howard W. Miner

OUTLINING the basic factors of sand control in the foundry through the use of colored slides, Adrian C. Den Breejen, Hydro-Blast Corp., Chicago, brought to members of the Northern Illinois - Southern Wisconsin chapter a most spectacular technical session. Speaking at the April 10 meeting in Beloit at the Hotel Hilton, the lecturer emphasized the importance of sand reclamation and how grain size, shape and color are related to sand problems.

Detroit Nominates Men for Offices in 1945-46

THE Detroit chapter has nominated the following men for office next year: E. C. Hoenicke, Eaton Mfg. Co., chairman; A. H. Allen, Penton Publishing Co., vice-chairman; W. W. Bowring, Frederic B. Stevens, Inc., treasurer, and H. H. Wilder, Vanadium Corp. of America, secretary. New directors which have been nominated include R. G. McElwee, Vanadium Corp. of America; G. Vennerholm, Ford Motor Co.; G. A. Fuller, Federal Foundry Supply Co.; and J. P. Carritte, Jr., True Alloys, Inc.

(Continued on Page 92)

CHAPTER ACTIVITIES

(Continued from Page 90)

Users of Castings Talk to Detroit

By H. H. Wilder

MEMBERS of the Detroit Chapter met March 15 at the Rackham Educational Memorial. Following the dinner, a war film, "Return to Guam," was shown.

Chapter Chairman R. G. McElwee, Vanadium Corporation of America, Detroit, then introduced L. A. Danse, General Motors Corp., who started the "Casting Users" discussion by introducing three Chief Inspectors of plants not having foundries, but which are large users of castings, purchased in the competitive field, as follows: H. J. Havermail, General Motors Truck; S. A. Klapp, Detroit Transmission; A. A. Weideman, Detroit Diesel.

Each of the three men covered separate problems encountered with foundries engaged in supplying castings. The main requirements set forth were: Physical Specifications, Freedom from Chill and Hard Areas, Dimensional Accuracy, Target Locations, and Control of Product.

Contact between foundry, engineering department, inspection and purchasing was emphasized as being the important means of control. Following the presentation, a number of interesting comments were made by both the foundrymen and inspectors present.

Non-Destructive Testing by Frear at Canton Meeting

By Nils E. Moore

THE Canton District chapter met on March 22 at the Elks Club where 87 members and guests heard Clyde L. Frear, senior materials engineer, Bureau of Ships, U. S. Navy, give an illustrated talk on "Non-Destructive Testing." The lecture was begun with the author explaining the source and nature of Gamma and X-ray and their relation to radio, visible and cosmic

(Continued on page 94)

CHAPTER ACTIVITIES

(Continued from Page 92)

waves. In spite of its inherent scientific complexity, the subject was presented in such a manner that members of the audience not familiar with physics could easily understand. The application of Gamma and X-ray in ferreting out faulty castings along with slides illustrating actual problems took up the greater part of the lecture. The remarks on magnetic testing were of interest to many, judging from the number of questions asked by the listeners.

Metropolitan Draws Capacity Crowd

By Geo. F. Hadzima

A CAPACITY crowd turned out to hear H. W. Dietert, Harry W. Dietert Co., Detroit, talk on "Mold Atmosphere Control" at the March 5 meeting of the Metropolitan Chapter, held at the Essex House, Newark, N. J.

The speaker showed, by the use of colored movies and lantern slides, some of the reactions that occur inside sand molds as they are filled with molten metal. The effect of oxidizing and reducing gas atmospheres on the temperature and rate of metal penetration into the sand mold was demonstrated.

Also, the effect of addition agents to the mold, such as sea coal, coke and sugar, was discussed by Mr. Dietert and illustrated in colored movies. The technique of looking inside of molds with a movie camera at temperatures as high as 2700° F. is unique and opens a field of research which is shedding new light on what actually goes on at the metal-sand interface. The knowledge gained from these studies will be extremely useful in establishing and maintaining better control in the foundry.

Philadelphia Hears Sefing On Non-Ferrous Work

By B. A. Miller

F. G. SEFING, International Nickel Co., New York City, was the speaker at the March meeting of the Philadelphia chapter, held at the Engineers' Club.

The eighty members and guests present definitely agreed that this was by far the most outstanding meeting, both in interest and questions, held this year. The speaker, using slides, demonstrated the importance of using correct gates and risers for the manufacture of all kinds of castings, be they ferrous or non-ferrous. Each slide was discussed by Mr. Sefing, and the numerous questions asked from the floor clearly showed how conscious the Philadelphia foundrymen are of the proper gates and risers that are to be used for a given casting.

The meeting was under the direction of technical chairmen Charles Schley, Philadelphia Bronze and Brass Corp., and Charles Mooney, Olney Foundry Div., Link Belt Co.

T. E. Barlow Is Speaker At Rochester Meeting

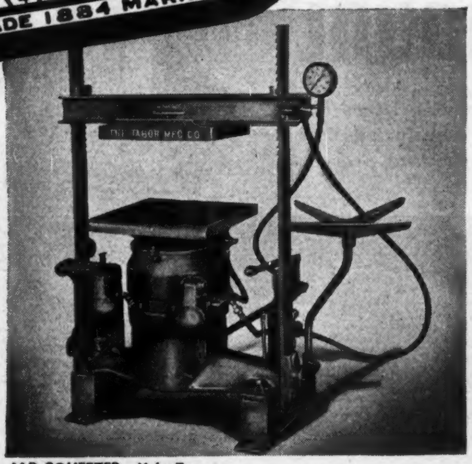
By D. E. Webster

APPROXIMATELY 75 members and guests attended the Rochester Chapter's March 8 meeting at Hotel Seneca. Following a

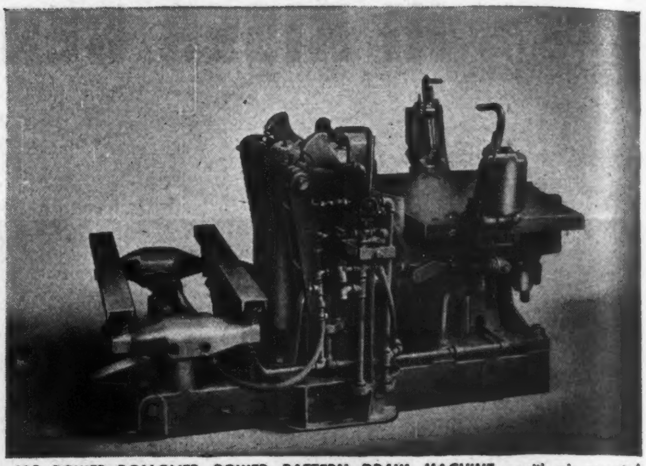
(Continued on Page 100)

FOUNDRY MOLDING MACHINES

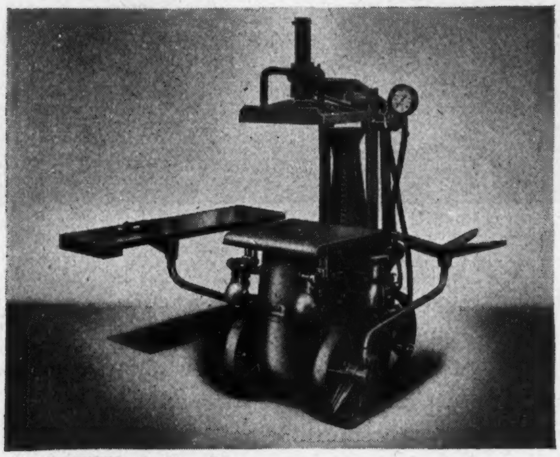
TABOR
TRADE 1884 MARK



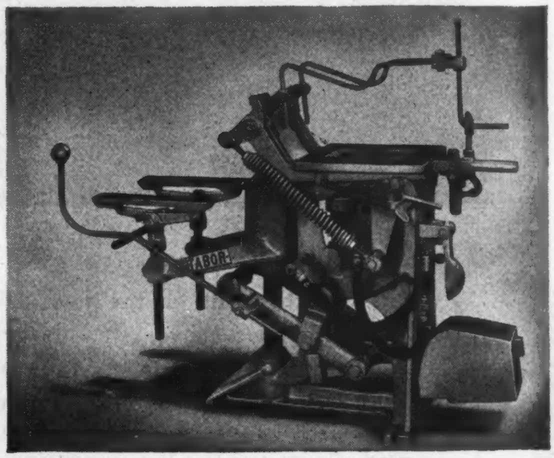
JAR SQUEEZER—Yoke Type



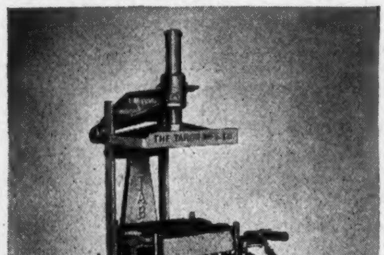
JAR POWER ROLLOVER POWER PATTERN DRAW MACHINE — with air operated flask clamps



JAR SQUEEZER—Cantilever Type



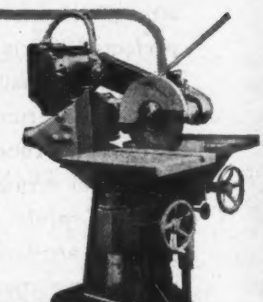
JAR-RAM HAND ROLLOVER HAND DRAW MACHINE



PORTABLE JAR SQUEEZE FLASK-LIFT MACHINE—with adjustable lifting pins.

. . . and TABOR-BRASIVE CUT-OFF MACHINES

Save time, labor and money in cutting gates and risers from castings of manganese bronze, aluminum bronze, nickel, Monel and other non-ferrous alloys, as well as alloy steel. Built in sizes and types to meet any cutting need.



MEMBER

MANUFACTURER'S ASSOCIATION, INC. FOUNDRY EQUIPMENT

The several types shown here are representative of the complete line of Tabor Foundry Molding Machines. Tabor can supply the right type of machine for any molding need . . . to gray iron, steel and non-ferrous foundries of any size.

Write us regarding your foundry machine requirements.

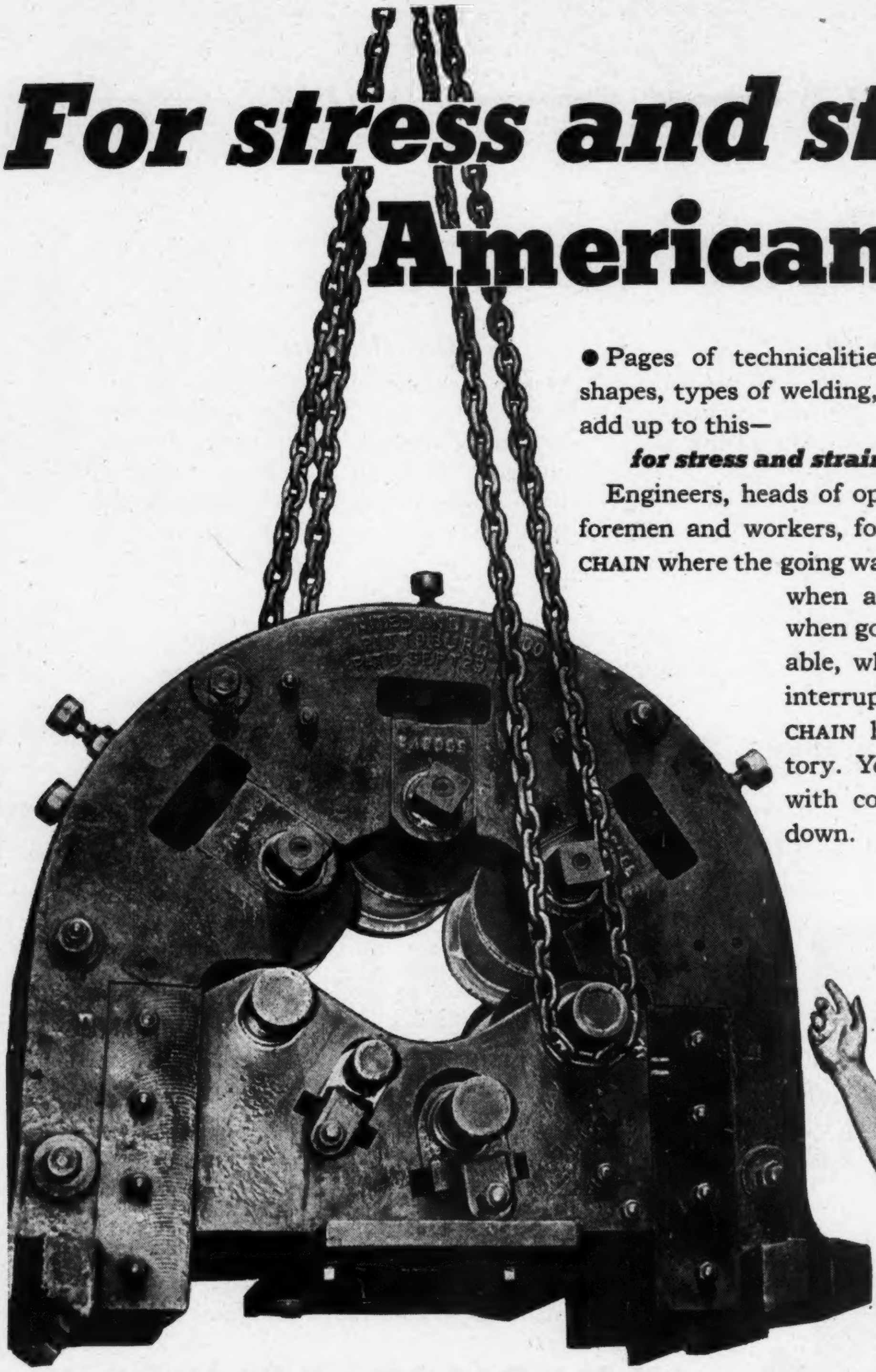
Since 1884 . . . MANUFACTURERS OF FOUNDRY MOLDING MACHINES

THE TABOR MANUFACTURING CO.

6225 Tacony Street • Philadelphia 35 • Pennsylvania

Representatives: Snyder Foundry Supply Co., Los Angeles, Calif.; Pacific Graphite Works, Oakland, Calif.; Carl F. Miller & Co., Seattle, Wash.

For stress and strain...
American Chain



● Pages of technicalities regarding materials, link shapes, types of welding, working loads and tests, all add up to this—

for stress and strain use American Chain.

Engineers, heads of operations, purchasing agents, foremen and workers, for years have used AMERICAN CHAIN where the going was tough. Under war pressure when accidents can't be tolerated, when good men are almost irreplaceable, when production must not be interrupted—demand for AMERICAN CHAIN has been highest in our history. You can use AMERICAN CHAIN with confidence. It won't let you down.

Weldless Chain is being substituted successfully in many applications, for welded chain and Manila rope. Write us about your chain and rope problems. Orders should be accompanied by highest possible preference ratings.

AMERICAN CHAIN DIVISION

York, Pa., Boston, Chicago, Denver, Detroit, Los Angeles, New York, Philadelphia, Pittsburgh, Portland, San Francisco

AMERICAN CHAIN & CABLE COMPANY, Inc.
BRIDGEPORT • CONNECTICUT

ESSENTIAL PRODUCTS... TRU-LAY Aircraft, Automotive, and Industrial Controls, TRU-LOC Aircraft Terminals, AMERICAN CABLE Wire Rope, TRU-STOP Brakes, AMERICAN Chain, WEED Tire Chains, ACCO Malleable Castings, CAMPBELL Cutting Machines, FORD Hoists, Trolleys, HAZARD Wire Rope, Yacht Rigging, MANLEY Auto Service Equipment, OWEN Springs, PAGE Fence, Shaped Wire, Welding Wire, READING-PRATT & CADY Valves, READING Electric Steel Castings, WRIGHT Hoists, Cranes, Presses... *In Business for Your Safety*

CHAPTER ACTIVITIES

(Continued from Page 94)

few introductory remarks, Chapter President W. F. Morton, Anstice Co., Inc., Rochester, introduced T. E. Barlow, Battelle Memorial Institute, Columbus, the principal speaker.

Mr. Barlow's talk, "Ladle Inoculation," proved to be extremely interesting, in that he pointed out with emphasis its purpose, effect and limitations. He classified inoculants into two distinct types, graphitizing and stabilizing.

Mr. Barlow also emphasized the difference between inoculants and alloys, which should not be confused in that the former depends for their success on microstructure as distinguished from alloys, which affect the principal composition. The speaker also stated that the effect of inoculation may be lost if metal is held more than 10 to 15 minutes before pouring.

The newly organized Portland chapter was visited by Bob Kennedy, Secretary, A.F.A., and is with A. G. Hobson, Western Foundry Co., secretary-treasurer of the "baby" chapter.

Sand Is Subject at Western New York

By J. Ralph Turner

CHAIRMAN REINHOLD D. LOESCH, Lake Erie Foundry Co., Buffalo, presided at the March 2 meeting of Western New York Chapter, held at Hotel Touraine, Buffalo, which featured Robert L. Doelman, Harry W. Dietert Co., Detroit, as the speaker.

Approximately 135 members and guests were present to witness a father and son act when Myron L. Doelman, National Engineering Corp., Buffalo, the Technical Chairman, introduced Mr. Doelman, Jr., as the speaker of the evening.

"Sand Affects Casting Finish" was the title of Robert Doelman's talk. According to the speaker, to combat any defect problem due to sand, we must first of all recognize the defect, logically analyze its cause and contributing factors, and then carry out the cure.

Although a casting defect is usually the result of an inherent weakness, a lack or excess of a definite physical or chemical characteristic which makes the sand behave as it does, the definite cause of a casting defect arises not from a single factor, but from a group of factors that affect or aggravate the definite cause. To permanently cure a particular defect, the prime cause must be eliminated.

After a description of the more common defects, the speaker changed over to movies and presented one of their latest research project reports, entitled "Mold Atmosphere Control," which dealt with what the speaker called "Oxidation Penetration."

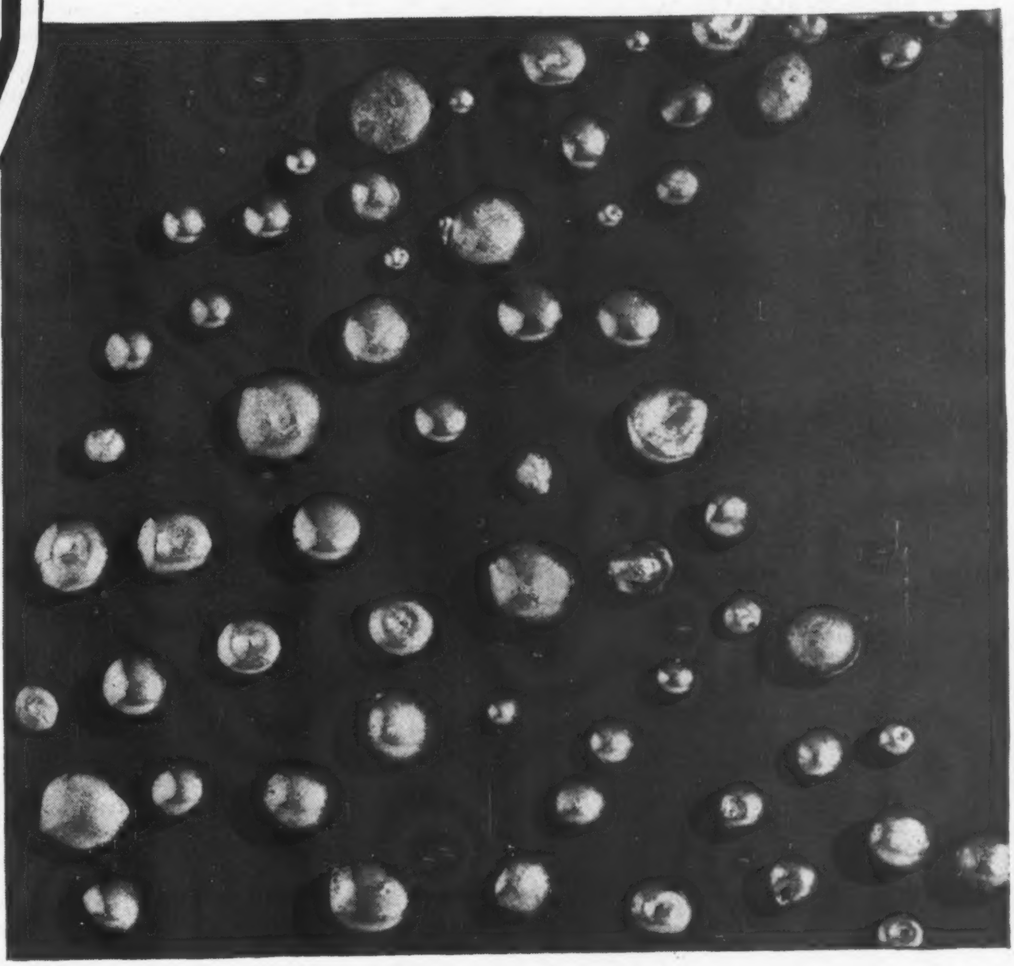
The test sand specimen was made up with a metal test pin inserted in the center and tested at various temperatures in a dilatometer. Penetration of the metal pin into the sand specimen was very evident at elevated temperatures when oxygen and air were used in the furnace.

When the furnace was filled with natural gas to obtain a reducing atmosphere the test pin was in fairly good condition and no penetration was noticeable. This effect was confirmed by making molds in a foundry and filling the molds with an acetylene gas which was ignited before pouring the mold. The surface of the casting was very clean, showing little oxidation penetration.

Other tests were made with oxidizing gases and other materials, to give a glazing action on the sand specimen and showed various results. The object of the movie was to show that by incorporating mold atmosphere control so that the gases in the mold are not oxidizing, much of the work in the cleaning room possibly may be eliminated.

The speaker emphasized that this work was not at all complete nor conclusive, but was merely presented to promote discussion on the subject. The meeting concluded with a lengthy question and answer period.

(Continued on Page 102)



Sims and Halliwell Lead Central Ohio Dual Meet

By Frank Kiper

A DUAL meeting was held by the Central Ohio chapter on March 26, at the Ft. Hayes Hotel, Columbus, Ohio. C. E. Sims, Battelle Memorial Institute, addressed the Steel Group and Geo. P. Halliwell, H. Kramer & Co., Chicago, talked to the Non-Ferrous Group.

Mr. Sims outlined the principles involved in electric steel manufacture, and emphasized the difficulties encountered resulting from improper de-oxidation and from gases other than oxygen.

Before the Non-Ferrous Group, Mr. Halliwell presented a paper on manganese and aluminum bronzes. The physical chemistry of these alloys was discussed.

Plastics Interest Central Indiana Foundrymen

By Robert Langsenkamp

H. K. NASON, director of development, Monsanto Chemical Co., Dayton, Ohio, was the speaker at the April 2 meeting of the Central Indiana chapter held at the Athenaeum, Indianapolis, Ind. Mr. Nason's subject was "Plastics" and his illustrated talk showed various methods of fabrication, along with problems encountered in each process. His slides showed curves of tensile strength and elongation at given temperatures of various types of plastics, in comparison with steel, bronze and aluminum alloys. The sample parts brought along included sections of aircraft propeller blades of impregnated wood; flexible hose and multi-colored plumbing accessories.

Reports on Chapter Activities

Officers and representatives of A.F.A. chapters who report on local activities in this issue are identified below:

Birmingham—J. P. McClendon, Stockham Pipe Fittings Co., Birmingham; Chapter Reporter, p. 79.

Canton District—Geo. M. Biggert, United Engineering & Foundry Co., Canton, Ohio; Chapter Secretary, and Nils E. Moore, Wadsworth Testing Laboratory, Wadsworth, Ohio; Chapter Reporter, pp. 76, 92.

Central Indiana—Robert Langsenkamp, Langsenkamp-Wheeler Brass Works, Inc., Indianapolis; Chapter Secretary, p. 102.

Central New York—John Feola, Crouse-Hinds Co., Syracuse, N. Y.; Chapter Reporter, p. 78.

Central Ohio—Frank Kiper, Ohio Steel Foundry Co., Springfield, Ohio; Chapter Secretary, p. 102.

Chicago Junior Foundrymen—Chester Celenga, Crane Technical High School, Chicago, Ill.; Chapter Secretary, p. 80.

Cincinnati—Jos. Schumacher, Hill & Griffith Co., Cincinnati; Chapter Secretary, p. 90.

Detroit—H. H. Wilder, Vanadium Corp. of America, Detroit; Chapter Reporter, pp. 81, 92.

Eastern Canada and Newfoundland—Robt. E. Cameron, Webster & Sons, Ltd., Montreal; Chapter Secretary, p. 76.

Metropolitan—Geo. F. Hadzima, Robins Conveyors Inc., Passaic, N. J.; Chapter Director, p. 94.

Northeastern Ohio—W. G. Gude, THE FOUNDRY, Cleveland, Ohio; Chapter Reporter, p. 80.

Northern California—Richard Vosbrink, Berkeley Pattern Works, Berkeley; Chapter Reporter, p. 80.

Northern Illinois-Southern Wisconsin—Howard W. Miner, Fairbanks, Morse & Co., Beloit, Wis.; Chapter Secretary, p. 90.

Philadelphia—B. A. Miller, Cramp Brass & Iron Founders Div., Baldwin Locomotive Works, Eddystone, Pa.; Chapter Director, pp. 80, 94.

Quad City—H. L. Creps, Frank Foundries Corp., Moline, Ill.; Chapter Secretary, p. 76.

Rochester—Donald E. Webster, American Laundry Machinery Co., Rochester; Chapter Secretary, p. 94.

Saginaw Valley—J. J. Clark, Saginaw Malleable Iron Div., General Motors Corp., Saginaw, Mich.; Chapter Reporter, p. 79.

Texas—L. G. Stenzel, Stenzel Pattern Works, Houston; Chapter Reporter, p. 75.

Twin City—H. F. Scobie, University of Minnesota, Minneapolis, Minn.; Chapter Reporter, p. 78.

Western New York—J. Ralph Turner, Queen City Sand & Supply Co., Buffalo; Chapter Secretary, p. 75.

ABSTRACTS

(Continued from Page 82)

Precision Casting

MOLDING MATERIALS. *"Refractory Molds for Precision Casting,"* Jules W. Glaser, THE IRON AGE, February 8, 1945, vol. 155, no. 6, pp. 52-57.

The characteristic properties of precision castings are the result of two features of the precision casting process: the method used to prepare the refractory mold, and the application of pressure to the metal during solidification. In this article the author considers the materials and methods for producing the refractory molds. Much of his discussion is devoted to a material which consists of a mixture of refractory particles and a binder made from ethyl silicate.

Precision Casting

WAX PATTERNS. *"Casting Cutting Tools From High Speed Steel Scrap,"* J. Albin, THE IRON AGE, March 1, 1945, vol. 155, no. 9, pp. 54-57.

Most of this article describes an injection molding process whereby expendable wax patterns for small parts may be made. The process is in use at Camp Legion, Dearborn, Michigan, a camp sponsored by Henry Ford for war veterans having a medical discharge.

Promotion

CASTINGS. *"Prospects for Cast Metals,"* Donald J. Reese, CANADIAN METALS AND METALLURGICAL INDUSTRIES, February, 1945, vol. 8, no. 2, pp. 38-40.

A description of present day conditions within the foundry industry which suggest the desirability of a broad program for educating consumers in regard to the merits of foundry products.

Radiography

FLUOROSCOPIC INSPECTION. *"A Practical Comparison of Fluoroscopy and Radiography,"* R. W. Mayer, INDUSTRIAL RADIOGRAPHY, Winter Number, 1944-45, vol. 3, no. 3, pp. 28-35.

The author has compared x-ray and fluoroscopic inspection, emphasizing the advantages of fluoroscopic inspection and some of the practices which must be observed in order to use it with the maximum efficiency.

Radiography

GAMMA-RAY. *"Adjustable Radium Capsule Support,"* J. Bland and E. Banks, Jr., INDUSTRIAL RADIOGRAPHY, Winter Number 1944-45, vol. 3, no. 3, pp. 23-25.

The authors describe a radium capsule support which combines flexibility and portability, and eliminates many of the difficulties previously encountered in gamma-ray inspection.

Radiography

PROTECTION. *"Industrial Radiation Hazards,"* C. B. Braestrup, INDUSTRIAL RADIOGRAPHY, Winter Number, 1944-45, vol. 3, no. 3, pp. 37-41.

The author discusses adequate protection from radiation, placing particular emphasis on the importance of considering all factors, rather than merely tube voltage, in determining the degree of protection needed. Such factors include milliampere-minutes of exposure and the distance to the X-ray tube target.

Steel

HARDENABILITY. *(See Testing.)*

Steel

ENAMELING. *"New Titanium Steel for Vitreous Enameling,"* G. F. Comstock and E. Wainer, THE IRON AGE, February 15, 1945, vol. 155, no. 7, pp. 60-63, 152-153.

The use for vitreous enameling of a steel containing an amount of titanium equal to or greater than approximately five times the carbon content has many advantages. Enamel boiling is eliminated and consequently the application of a cover coat preceding white enamel coats is unnecessary. Furthermore, the drawing qualities of high titanium steel are excellent. The steel should have a low carbon content and must be deoxidized with aluminum before the titanium alloy is added. Great care must be taken in finishing and cleaning the surfaces to which enamel is to be applied.

Steel

TOOL STEELS. *"Chart of Comparable Tool Steels,"* prepared by Ralph G. Sartorius, THE IRON AGE, February 1, 1945, vol. 155, no. 5, pp. 44-47.

A supplement to the directory of "1500 Tool Steels," published serially in THE IRON AGE and available in booklet form.

The tables present the trade names and manufacturers of the nine classifications of tool steels and summarize the application, approximate heat treatment, and chemical composition of each type not strictly within the classification type analyses.

Testing

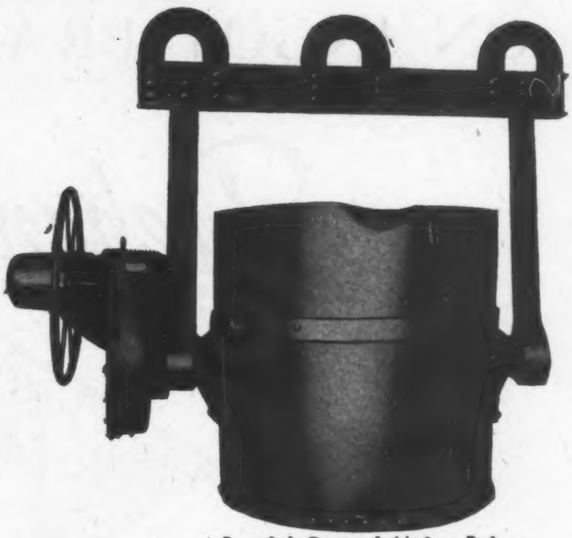
HARDENABILITY. *"Magnetic Measurement of the Hardenability of Carbon Tool Steels,"* C. B. Post and W. H. Fenstermacher, METAL PROGRESS, February, 1945, vol. 47, no. 2, pp. 286-288.

The authors describe a method whereby the hardenability of tool steels may be determined by measuring the current necessary to create a field which is just sufficient to demagnetize a hardened cone-shaped specimen which has been previously prepared for this test.

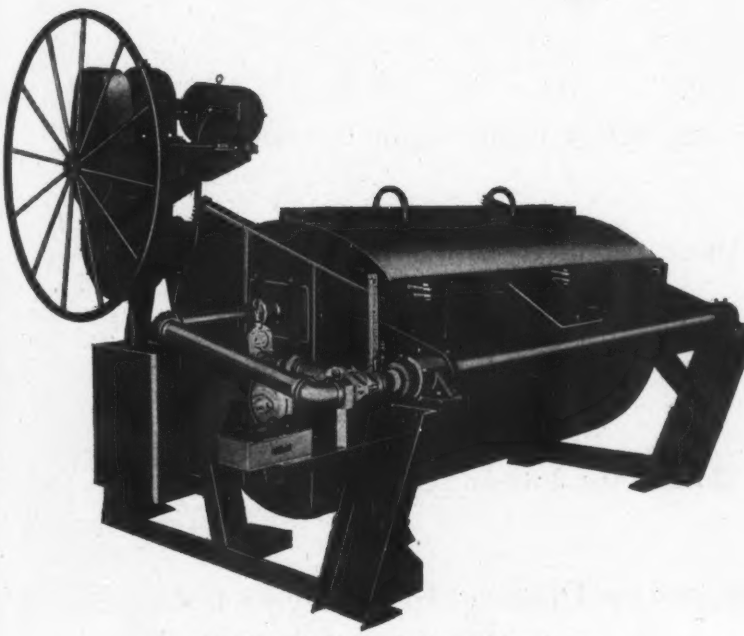
Testing

HARDNESS. *"Rockwell Hardness (Diamond Penetrator) of Cylindrical Specimens,"* W. L. Fleischmann and R. S. Jenkins, METAL PROGRESS, February, 1945, vol. 47, no. 2, pp. 275-277.

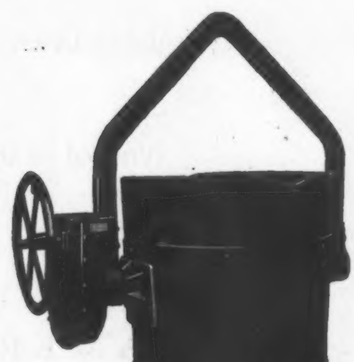
The authors have shown that hardness readings taken on cylindrical surfaces and flat surfaces of the same specimen vary considerably. Less variation occurs on surfaces with larger radii of curvature or alloys having a high hardness. The authors worked out correction charts, by the aid of which readings taken on cylindrical surfaces may be corrected to those taken on flat surfaces. The same general technique of testing is observed, great care being taken to see that the axis of the cylindrical piece is normal to the axis of the penetrator. If the hardness of the specimen is below C-20, exact results cannot be expected.



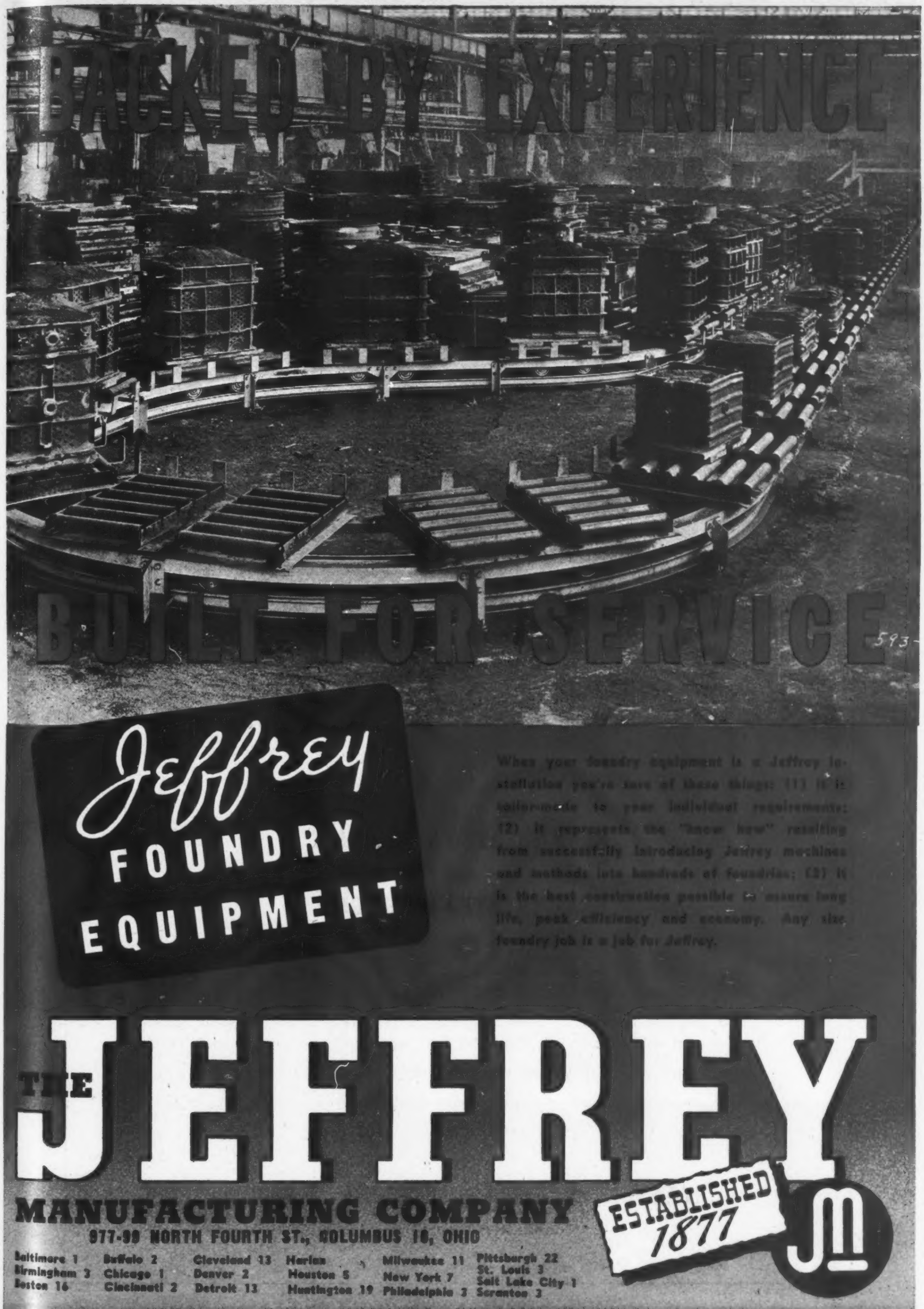
Special Geared Motor Driven Crane Ladle

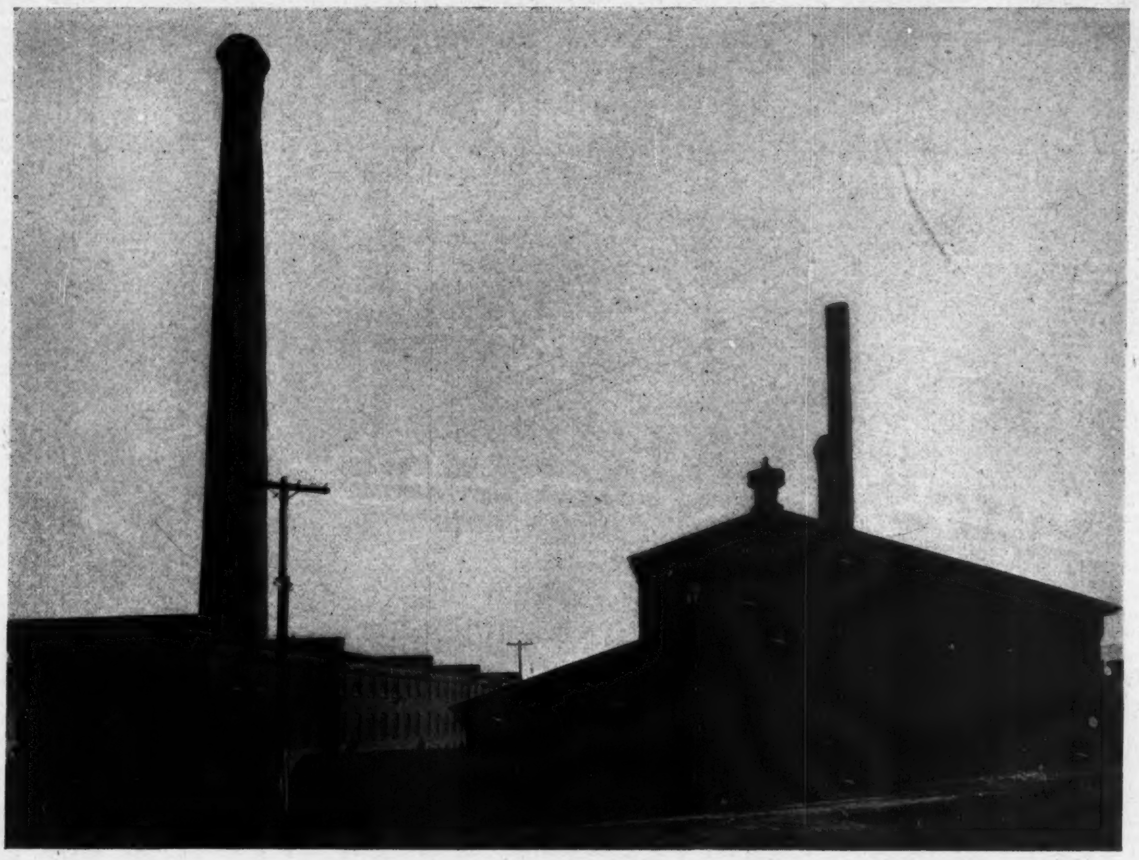


Special Geared Motor Driven Mixing Ladle



Geared Crane Ladle


BACKED BY EXPERIENCE
BUILT FOR SERVICE
593
Jeffrey
FOUNDRY
EQUIPMENT
When your foundry equipment is a Jeffrey installation you're sure of these things: (1) it is tailor-made to your individual requirements; (2) it represents the "know how" resulting from successfully introducing Jeffrey machines and methods into hundreds of foundries; (3) it is the best construction possible to assure long life, peak efficiency and economy. Any size foundry job is a job for Jeffrey.
THE JEFFREY
MANUFACTURING COMPANY
977-99 NORTH FOURTH ST., COLUMBUS 16, OHIO
ESTABLISHED 1877
Baltimore 1
Birmingham 3
Boston 16
Buffalo 2
Chicago 1
Cincinnati 2
Cleveland 13
Denver 2
Detroit 13
Harlan
Houston 5
Huntington 19
Milwaukee 11
New York 7
Philadelphia 3
Pittsburgh 22
St. Louis 3
Salt Lake City 1
Scranton 3



We know you are anxious to lick tough and difficult blasting and cleaning jobs.

That is where we come in.

By using our—

HEAT-TREATED STEEL SHOT

and

HEAT-TREATED STEEL GRIT

you can not only blast quickly—you can, also, save from 10% to 20% in cost.

Our products have been tested and proven superior in quality by the largest consumers all over the world who buy from us regularly.

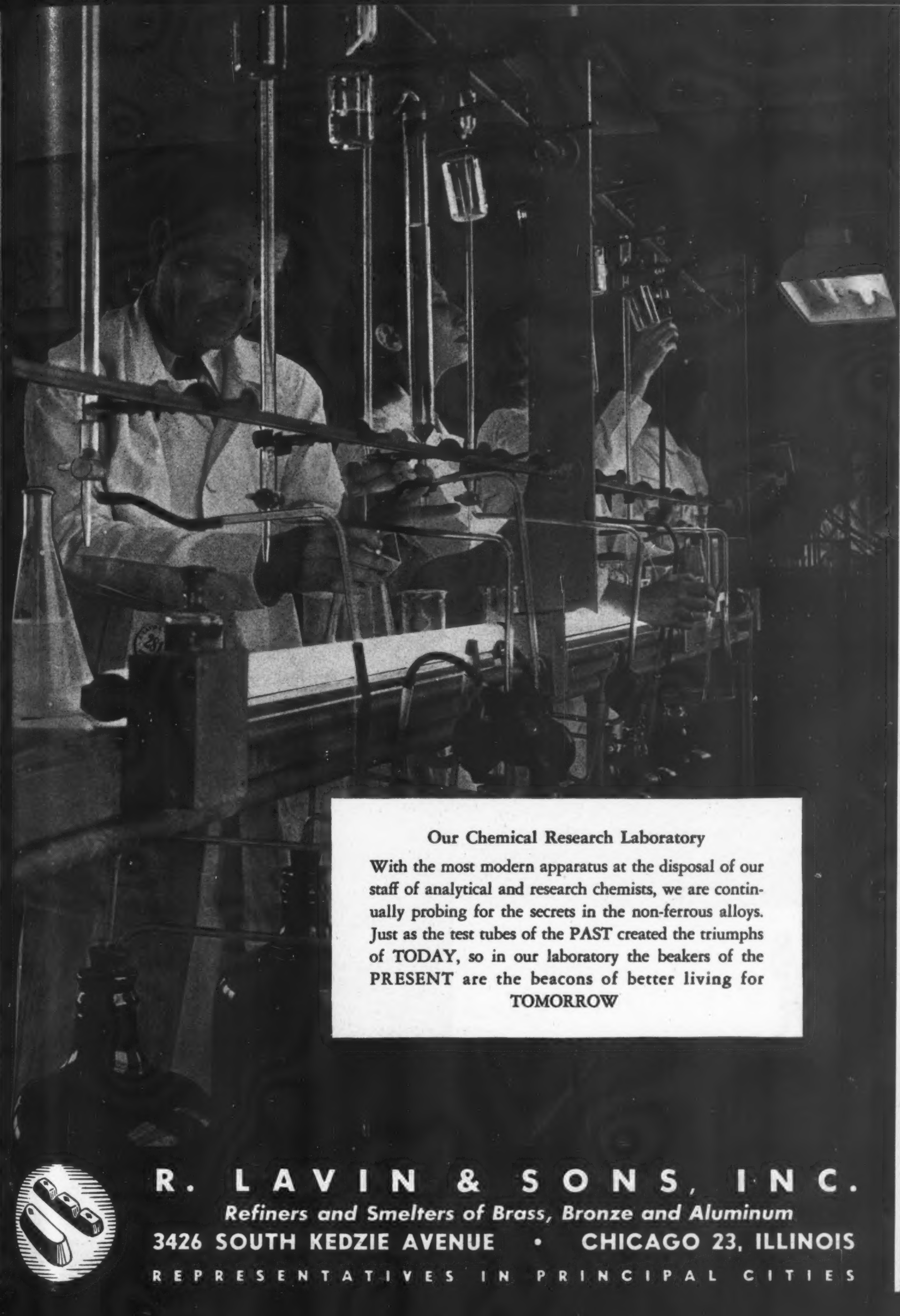
You get the benefit of over 50 years experience in developing, manufacturing and selling quality Shot and Grit when you purchase from us.

It will pay you well to test our products thoroughly at once.

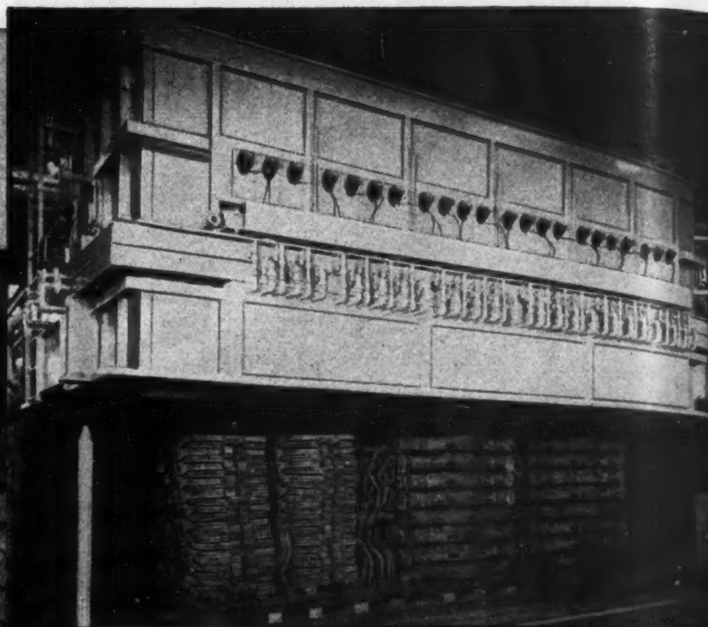
And, most important—our Shot and Grit costs no more than ordinary cast iron Shot and Grit.

HARRISON ABRASIVE CORPORATION

Manchester, New Hampshire


Our Chemical Research Laboratory
With the most modern apparatus at the disposal of our staff of analytical and research chemists, we are continually probing for the secrets in the non-ferrous alloys. Just as the test tubes of the PAST created the triumphs of TODAY, so in our laboratory the beakers of the PRESENT are the beacons of better living for TOMORROW
R. LAVIN & SONS, INC.
Refiners and Smelters of Brass, Bronze and Aluminum
3426 SOUTH KEDZIE AVENUE • CHICAGO 23, ILLINOIS
REPRESENTATIVES IN PRINCIPAL CITIES

A WILSON Rectangular Bell Furnace Application for Malleableizing Iron Castings at The Eastern Malleable Iron Co., Wilmington, Del.



● A Wilson Gas Fired Rectangular Bell Type Furnace — Gas Tight Casing. Atmosphere self-generated from the contained carbon in the cast metal.

● Fired with Wilson Vertical Radiant Tubes for low fuel consumption. Uses any type of industrial gas.

● Eastern Malleable Iron Co.'s excellent loading method makes for heavier charges, lower fuel cost per ton, quick handling, more heats per year.

ENGINEERED AND CONSTRUCTED BY THE

Lee Wilson ENGINEERING Co., Inc.

20005 West Lake Road CLEVELAND, OHIO
Telephone ACademy 4670

The Wilson Annealing Unit is covered by Patents Nos. 1,932,402, 2,068,477, 2,078,356, 2,081,612, 2,089,043, and other patents pending

INDUSTRIAL FURNACES ★ RADIANT TUBE HEATING ★ HEAT TREATING PROCESSES

Use

VELSICOL

Core Oils

VELSICOL

Only Velsicol Core Oils contain the unique *Coresin* base

Write to the representative in your territory or direct to us for complete information and Samples.

VELSICOL Corp.

General Offices: 120 East Pearson Street, Chicago • Plant: Marshall, Illinois

HERE'S HOW HOFFMAN VACUUM CLEANING HELPS SPEED WAR PRODUCTION!

Use Hoffman vacuum to eliminate dusts that are health hazards and to improve working conditions. But don't stop there. Put it to work on production jobs, too. There are many applications in the foundry where the use of specialized Hoffman vacuum equipment brings about definite savings in time and cost. For instance, how about using Hoffman vacuum for cleaning open moulds? It quickly removes all loose sand and foreign matter—eliminates the cause of many flawed and faulty castings. Let us tell you about other jobs for vacuum in the foundry—and show you how to use it to increase your war production.

MOULD CLEANING by vacuum methods is better, faster and less expensive. Hoffman vacuum eliminates costly compressed air; overcomes objectionable and unsafe blowing of sand and dust.

BLASTING SHOT frequently becomes lodged in cavities of large and intricate castings. Hoffman vacuum recovers the shot; many plants are making very substantial savings through reclamation of shot.

DEEP INTRICATE MOULDS like this one are effectively and rapidly cleaned. A special Hoffman lance-type nozzle reaches the inner recesses of the mould, quickly pulls out loose sand and foreign matter.

U.S. HOFFMAN MACHINERY CORPORATION
AIR APPLIANCE DIVISION, 111 FOURTH AVE., NEW YORK